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Integrated management system for the Bureau of Yards and Docks.

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INTEGRATED MANAGEMENT SYSTEM FOR THE BUREAU OF YARDS AND DOCKS

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PREFACE

Although the title of this thesis indicates the scope of the study will cover the entire gamut of Bureau management, perusal will reveal a noticable lack of mention of utilities, transportation, and real estate management. Omission of these activities, except for brief recognition of transportation management in Chapter III, is not done with the purpose of slighting these essential functions. Realizing, however, the necessity of keeping the subject matter within reasonable limits, I have chosen to emphasize facility management since it is the area of major management effort.

It must also be noted that the need for and the basic concept of integrated management within the Bureau of Yards and Docks are ideas that are certainly not original with this writer. Both the need and the concept have been long recognized within the Bureau organization. The specific purpose of this thesis, therefore, is to present the framework of a system of facilities management which, it is believed, will provide a practical and workable solution to these underlying needs.

Subsequent to the completion of this thesis, the Secretary of the Navy's decision concerning realignment of the facility maintenance responsibilities was published. By this decision, the Bureau of Yards and Docks will assume management control over all facilities maintenance. It is considered that this realignment of management responsibilities will not invalidate the proposals presented herein, in fact, it should facilitate their use.

LIST OF ILLUSTRATIONS

CHAPTER I

INTRODUCTION

Defense spending will exceed $55.0 billion in the proposed Fiscal Year 1964 budget. The armed forces have a moral as well as a legal obligation to the taxpayers to obtain maximum utilization of these dollars. This is particularly true in the world of today when there are so many demands on Uncle Sam's bank account.

Included in the responsibilities assigned to the U. S. Navy is the task of managing the public works, public utilities, real estate, and construction and transportation equipment within the Naval Shore Establishment. Management of these facilities exceeds $500 million per year. In addition, the average appropriation for new construction during the period Fiscal Year 1959-1963, was approximately $185 million. A management program of this size requires methods and procedures which will insure, to the greatest extent possible, the maximum return on the taxpayer's investment.

Interest in the Navy's facility programs is widespread in the Congress and in the Executive Branch. The Congressional interest in military construction is exemplified by the Fiscal Year 1963 appropriation hearings in the House of Representatives in which there were 268 pages of testimony in support of $161 million of Navy military construction funds, compared to 164 pages of testimony for $7.1 billion of Navy procurement funds. Congressional interest in facility maintenance is demonstrated by the Fiscal Year 1963 Department of

Defense Appropriations Act, the passage of which marked the first time that Congress, in appropriating operation and maintenance funds, has specified the minimum amount available for maintenance of real property facilities.[1] The Department of Defense, in turn, has expressed a desire to improve the analysis of program requirements in the area of the operations and maintenance appropriation.[2] Within the Navy, the emphasis on facility management is demonstrated by the Secretary of the Navy's policy of consolidation of public works activities to achieve more economical and efficient operations.[3] In addition, a study has just been completed of increased management effectiveness in the Navy. Although the outcome of the study is not known, the fact that such an analysis was conducted serves only to emphasize the other expressed interests in the various facets of Bureau of Yards and Docks management.

The need for improved management procedures has long been recognized by the Bureau of Yards and Docks, and many steps have been taken in this direction. An indication of their success was given by the Chief of the Bureau, who was able to report that despite an increase in the replacement cost of the Shore Establishment (less Marine Corps) from $17.6 billion to $18.6 billion, maintenance expenditures during Fiscal Year 1962 decreased from $308.7 million to $307.6 million.[4] The Bureau has also been aware for some time of the need for an integrated system of management as indicated by a Bureau *ad hoc* committee which is currently studying the adoption of this system.

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[1] *Public Law* 87-577.

[2] *Programming System for the Office of the Secretary of Defense, Study Report*, 25 June 1962, p. II-4.

[3] *SECNAVINST 5450.9* of 30 June 1960.

[4] "BuDocks Annual Report," *The Navy Civil Engineer*, III (Nov., 1962), 13.

In view of the widespread interest in Bureau of Yards and Docks management responsibilities, the time seems especially opportune for an independent review of the broad aspects of these responsibilities with a view towards adaption of the integrated systems management technique to the Bureau's requirements.

CHAPTER II

THE INTEGRATED SYSTEMS APPROACH

Prior to the study of actual management situations and systems applications in the Bureau of Yards and Docks organization, it is well to review the integrated systems approach in general. This review will be undertaken with a view towards answering the following questions: What is the integrated systems approach? What is its objective? What is its significance to management?

James D. Gallagher, a leading specialist in the commercial use of systems and data processing, defines this approach to management as follows:

> Such a system involves three basic elements. The first is the use of data-processing equipment involving computers and electronic input-and output devices for the rapid collection, manipulation, and tabulation of data. The second is the use of highly developed communication links between electronic computers and input-output devices so that one machine can 'talk' to another, or actually operate another, within the system. The final--and most important--element is the proper selection and arrangement of information for planning and control so as to form a system of reports which will give each manager the key facts he needs for decisions, underscoring especially the exceptions or abnormal situations needing his attention. If all three elements . . . are present, a good management information system exists.[1]

At this point it is well to note that authorities agree that although the utilization of electronic computers provides a system more capable of rapid accumulation and dissemination of information, a computer is not a mandatory element of management information systems. It can thus

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[1]James D. Gallagher, Management Information Systems and the Computer, Research Series No. 51, American Management Association (New York: AMA, 1961), p. 11.

be reemphasized that the most important element is a proper flow of information to management for decision making.

A familiar concept of the management information system is that shown in Figure 1.

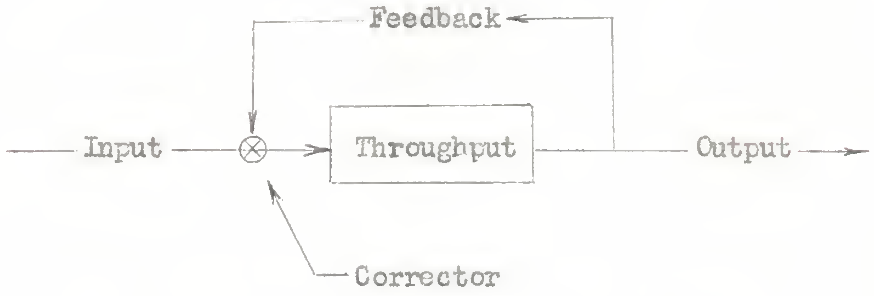

Fig. 1.--Information-Feedback System

Each of the components must be present in a viable system; however, feedback is perhaps the most important. The essence of the system is its ability to vary inputs in such a manner that the desired output will be achieved. Information-feedback systems have been present in their biological form since the beginning of life. In the context of political, social, and economic systems, information-feedback has been present for centuries, although perhaps their concept was too vague to be formally recognized. It was not until the 1940's that the formal information-feedback theory was developed simultaneously, although under differing circumstances, by Norbert Weiner and Claude Shannon. Following World War II, key contributions to information theory were published within a period of a few months, and originated in part from wartime research on automatic fire control systems, in the case of Weiner, and on secrecy codes, in the case of Shannon.[1] The schemes thus developed, and as ap-

[1]Robert M. Fano, Transmission of Information: A Statistical Theory of Communication (New York: The M. I. T. Press and Wiley and Sons, 1961), p. 1.

plied to organization management, have come to be known as integrated systems management, cybernetic management or information technology.[1] In any case the essential input-throughput-output-feedback-corrector components are present.

What is the objective of the systems approach to management? This can best be answered with one word--integration. Authorities recognize that business management has tended to become overly specialized. The manager specializes within his department where his day-to-day experience only serves to perpetuate the atmosphere of unrelated compartmentalization.[2] Any management must avoid a parochial point of view, yet traditional organization systems try to force managers in this direction. Tilles, a lecturer in business administration and production management, notes this by stating:

> One of the tragedies frequently suffered by people who fall in love with such traditional organization techniques as job descriptions and organization charts is that after a while they become far more concerned with specialization than with coordination. Somehow the inevitable result of boxes and lines appears to be the <u>division</u> of tasks, rather than merely their <u>delineation</u>. As a result, the neat little lines on the chart, which were originally intended to be boundaries, always seem to become fences.[3]

This is not to say that organization charts must become a thing of the past; however, the management techniques of tomorrow, which are now coming into wide-scale use in government and industry, are forcing subordinate and interrelated organizations to achieve this integrated systems approach if they are to be responsive to outside influences.

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[1]Harold J. Leavitt and Thomas L. Whisler, "Management in the 1980's," <u>Harvard Business Review</u>, XXXVI (June, 1958), 41.

[2]Jay W. Forrester, <u>Industrial Dynamics</u> (M. I. T. and New York: The M. I. T. Press and John Wiley and Sons, Inc., 1961), p. 2.

[3]Seymour Tilles, "The Manager's Job: A System's Approach," <u>Harvard Business Review</u>, XLI (Jan.-Feb., 1963), 79.

The systems approach allows management to overcome the compartmentalized approach; in fact, it forces management to change. The basis of the approach to systems analysis and design is to research the entire organization, beginning with its basic objectives. Systems analysis forces management to state exactly what is done, and what specific information is needed. Systems design revises the entire management process and recasts it into an integrated whole.

What is the significance of the systems method to management? The most important and far reaching affect of this approach is its influence on managers themselves. They must reorient their thinking from the specialized departmental approach to the conceptual approach. Managers must develop conceptual skills. They must become aware of their organization as a whole operation.

Culliton points out that managers must develop the concept of a consumer-oriented organization. Such an approach, however, makes the old kind of departmentalization untenable. A manufacturing department which makes only what is cheapest or easiest to make, or an engineering department which designs only what it likes illustrate a management approach which cannot survive in the conceptual atmosphere. The whole is not the sum of a good engineering department, a good production department, and good other departments. The whole is the consumer-oriented business, and it will be more or less healthy as it has parts which, in their interrelationships with each other, work for or against the whole.[1] Tilles, on the other hand, argues that customer satisfaction is only one measure of an organization's performance. Other factors which must also

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[1]J. W. Culliton, "Thinking Ahead: The Age of Synthesis," Harvard Business Review, XL (Sept.-Oct., 1962), 40.

be considered are the labor force (their opportunities and stability of employment), suppliers (rapidity of payment), creditors (adherence to contract terms), and competitors (rapidity of growth).[1] In either case it is apparent that the manager must develop a broader and much more all inclusive attitude.

No rational person would argue that precepts such as these are fallacious. Rather, it is surprising that there is such a proliferation of authoritative writing about this "new" approach to management. It is new in the sense that the size of big business and big government has caused many organizations to decentralize to the extent that top management has become, in many cases, completely isolated from important day-to-day operations while the day-to-day middle managers have tended towards overspecialization. This top management isolation and middle manager specialization complement one another in producing an organizational outlook that can easily become shortsighted in its method of operation. This writer was associated with an organization where the idea or thought of compartmentalization was strong enough that one division, when originating correspondence for the top executive's signature, would indicate that the scheme in question was approved or disapproved by Division X rather than by the overall organization. Although this administrative practice was soon corrected, one wonders how effective the correction was in terms of changing human feelings and beliefs. The systems approach offers management a way out of the maze; however, the approach is exacting in its demands for a new managerial outlook.

Discussion of the need for conceptual attitudes and the hazards of overspecialization are points which may fail to impart full appreciation

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[1]Tilles, <u>op. cit.</u>, p. 78.

of the benefits of the systems approach. What are some aspects of systems management which are more tangible or perhaps more realistic to the day-by-day management of the organization? Such benefits come from the availability of more accurate and more timely information. Lack of sufficient or timely information is a factor which has long plagued managers. The one extreme was the manager who postponed the final act of decision in the hope that more and better information would become available. The other extreme, the manager who jumped to conclusions, is described by one authority who states:

> Faulty practices constituting no more than a kind of 'folklore' . . . 'rules of thumb' and 'quickies' of one sort or another . . . have abounded in persistent managerial use for no better reason than that they have produced 'cheap' and 'simple' figures.[1]

The only reason such decisions are simple is because they fail to face reality.[2] Reality can be faced by the manager who has the information available when he needs it.

There are, however, those who argue that provision of additional information is neither necessary nor desired. Their attitude is that things worked all right for me so why should anyone else in that job need more information than I did? Samuel N. Alexander, Chief of the Data Processing System Division of the National Bureau of Standards, characterizes this problem by stating:

> We are emerging from a period in which much of a firm's data served as a historical or police function, rather than a managerial function and entering a period in which they can be made available to assist management. Therefore, this gray zone of data usage must be approached and approached effectively. There must be organizational procedures set up so that it can be discussed without people leaping at each other's throats and telling one another to mind their own business.

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[1]Ross G. Walker, "The Judgment Factor in Investment Decisions," Harvard Business Review, XXXIX (March, 1961), 93.

[2]Ibid.

> Tempers run high over such matters. I am myself (at least in theory) a neutral observer, and I have seen this situation appear repeatedly in every business activity and government operation I have had a chance to observe at close range. Conflicting personal opinions and interests do more to hamstring the (systems) approach than any other factor.[1]

The first reaction to a manager's denial of the need for more and better information is to say that this type of reasoning is absurd; however, there are those who are gifted with an uncanny knack of intuitiveness that never seems to fail. One wonders, however, how much better use could be made of this ability if it could only be channeled into those areas where it would really count. Surely the prospect of having sufficient data available to take the guess work out of what are actually routine decisions is not something to be cast aside. We are operating in the nucleonic, electronic, and jet propulsion age, yet our decision making is in the horse and buggy stage.[2]

It seems, therefore, that organizations in general, and particularly the large decentralized types, are suffering from information constipation. The tremendous growth of most organizations in the past two decades has isolated top management, forced it into a management by exception principle, and produced a shortsighted middle management philosophy. It would seem that the only way out of the problem is to provide a freer flow of information. This, however, is not the case. The problem is not solved merely by providing more information, or by faster accumulation and transmittal of data, or by wider distribution of previous data, or by holding more conferences. One of the major fallacies is thinking that such measures will provide a ready made solution. What is required is the overall

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[3]Samuel N. Alexander, "Integrated Data Processing: A Progress Report," Administrative Automation Through IDP and EDP, Office Management Series No. 144, American Management Association (New York: AMA, 1956), pp. 2-3.

[2]Melvin L. Hurni, "Decision Making in the Age of Automation," Harvard Business Review, XXX (Sept.-Oct., 1955), 49.

study of the organization system in its entirety to discover what information must be provided at what level.[1] A system is required which will integrate the parts into a meaningful whole, which will provide to each level of management the information which it needs to carry out its assigned responsibilities, and which will overtly orient the entire organization to a common objective.

Important aspects of the systems approach which should not be overlooked are the management science or operations research techniques. These methods, which consist of the application of the scientific approach to operational problems, emphasize the use of conceptual models for decision-making. Crawford classifies the several types of conceptual models according to the type of symbolic tool used (logic models or mathematical models), according to their function (descriptive models or policy models, i.e., those designed to provide a basis for evaluating courses of action), according to the degree of certainty of the variables (certainty models or probability models), or according to the type of decision to be made (single or multiple).[2]

Of the many business applications of operations research, two areas of interest are maintenance and investment. In the field of maintenance one single-decision policy model seeks to minimize total costs. The total costs are the variable cost of replacing parts failing in use, the variable cost of replacing parts used during scheduled maintenance, the cost of the parts wasted when replaced during maintenance, and fixed costs. When the first derivative of the equation expressing the relationship

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[1] Ibid., p. 51.

[2] Robert W. Crawford, "Operations Research and Its Role in Business Decisions," Selected Readings in Management, ed. Fremont A. Shull, Jr. (Homewood, Ill.: Richard D. Irwin, Inc., 1958), p. 141.

between these costs is set equal to zero to minimize total costs, the time to replace parts then becomes a function of the pattern of part failure, the variable cost of replacing one part failing in use, the variable cost of replacing one part during scheduled maintenance, and the cost of the part per unit time wasted.[1] In the investment problem, the alternatives studied may be the use of the present machine if replacement is involved, the use of a new machine of one particular type, or the use of alternative types of machines. The decision may be made on the basis of analyzing alternative annual costs, returns on the investment, or payout periods.[2] Although both examples cited pertain to equipment considerations, the methods are equally applicable to other areas of maintenance and investment.

Although analytical methods, such as those discussed above, provide considerable assistance to the manager in his decision making role, they cannot provide the maximum benefit unless properly used. Drucker points out that if the various management science methods are to help management reach its full potential, they must not be allowed to become the "management gadget bag" of techniques for the efficiency expert. Management science techniques must concentrate on the performance of the whole rather than the efficiency of the parts.[3] It is thus apparent that operations research, as a part of the management science approach, must come within the framework of the integrated systems concept. At its best, operations research is a systematic approach to a whole business considered as an integrated operation; it is the analysis of the interrelations

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[1]Ibid., p. 146.

[2]Ibid., p. 148.

[3]Peter F. Drucker, "Thinking Ahead: The Potentials of Management Science," Harvard Business Review, XXXVII (Jan.-Feb., 1959), 25-26.

of all the business functions.[1]

From the foregoing it is apparent that systems management techniques improve the decision making process in three basic ways: (1) The quantification of selected data will improve not only the amount of facts in a specific report dealing with a decision area, it will also improve the information content. (2) Decision making will be based on evaluation of a wider range of alternatives and of current factual data rather than on intuition and the extrapolation of historical data. This will be made possible through operations and decision simulation. (3) The impact of a decision in one functional area on another functional area of an organization will be more easily measured, and, as a result, a more comprehensive view of the organization's activities can be taken. This should lead to decisions which optimize the goals of the total organization, rather than any particular department or division.[2]

There are two further questions which should be considered to determine the full effect of the systems approach on management. The first of these is management judgment. The second is the effect of systems management on the organizational structure.

Authorities agree that a definite place remains for management judgment. The major effect of systems-type management is to facilitate decision making by giving the manager information which is more timely and accurate. As Gallagher notes, the decision cannot be an automatic response to the information input. The manager's judgment, and the responsibility for the consequences, will not be transferred to the data processing system, "at least not in the foreseeable future--and <u>never</u> in

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[1]Herbert Solow, "Operations Research in Business," <u>Fortune</u> (Feb., 1956), p. 148.

[2]Gallagher, <u>op. cit</u>., pp. 51-52.

the area of top management decision."[1] The existence of management sciences does not mean there will be automatic management. They do, however, provide a springboard from which to reach further by the exercise of managerial intelligence and judgment.[2] These facts are true despite the research work in highly sophisticated computer programs which point towards the design of programs presumably capable of making judgmental-type decisions. H. A. Simon, a leading authority in this research effort, indicates that even though basic discoveries about the nature of human problem solving seem to point toward a fundamental revolution in the area of judgmental decision making, "many, perhaps most, of the problems that have to be handled at the middle and high levels in management have not been made amenable to mathematical treatment, and probably never will."[3]

The question of the effect of the systems approach on organizational structure involves consideration of centralization as opposed to decentralization. Perhaps one of the most widely referenced works is that of Leavitt and Whisler who make several predictions concerning the information technology. The information technology should move upward the boundary between planning and performance. Planning will be taken from the middle managers and given to such specialists as operations researchers or operations analysts. Middle management jobs will become highly structured; they will be governed by operating rules that cover the day-to-day decision making process. Large organizations will recentralize. Top managers will take on even more of the planning, innovating, and other "creative" functions. Radical reorganization of the middle

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[1] Ibid., p. 56.

[2] Forrester, op. cit., p. 9.

[3] H. A. Simon, The New Science of Management Decision (New York: Harper Bros., 1961), p. 21.

management level will cause certain classes of jobs to move downward because they require less skill, while others (operations analysts, etc.) will move up. The line separating top and middle management will be drawn more clearly and more indelibly than ever before.

Top management is pictured as welcoming with open arms the recentralization tendency because any reduction in the number of middle managers will mean more economy. This feeling will persist despite the recognition of such compelling factors as the need to provide a top manager training ground through decentralization, the need to develop the "whole man", or to induce more active cooperation. The more information technology can reduce the number of middle managers, the more top management will want to try it. The organization of the future is pictured as a football balanced on the top of a bell. The football will contain the top staff organization who will deal with problems of coordination, individual autonomy, group decision making, and so on. Those in the bell will be dealt with quite differently and will have different means of control and communication.[1]

Other authorities predict quite the opposite. Forrester states that improved definition of objectives and more pertinent standards for measurement of managerial success will permit managers at the lower levels to take on <u>more</u> responsibility in a form which can be more effectively discharged.[2] Another viewpoint is that taken by Simon who states:

> The question is not whether we shall decentralize, but how far we shall decentralize . . . Automation of important parts of business data processing and decision making activity, and the trend toward a much higher degree of structuring and programming . . . will radically alter the balance of advantage between centralization and

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[1]Leavitt and Whisler, <u>op. cit</u>., pp. 41-48.

[2]Forrester, <u>op. cit</u>., p. 46.

> decentralization . . . new developments in decision making will tend to induce more centralization in decision making activities at middle-management levels.[1]

It would seem, therefore, that the systems approach to management will not completely banish middle management. If used correctly, it will bring the middle manager into even closer contact with the more dynamic and challenging features of the organization. This correct use would put into the middle manager's hands the information he needs to perform his tasks, knowing that his individual actions and those of his subordinates will be in line with top management policy. Another factor, which is just as important, is that it will give the middle manager insight into the overall organizational system so that he may become aware of the effect of his actions upon other parts of the organization.

It has not been this writer's intention to discuss all of the many details relative to system management in this chapter, but rather, to highlight some of the more important considerations behind the integrated systems movement in management. The basic principle behind this approach is improved, more realistic, and more rational management. This comes about through the increased availability of information. This information must be accurate, and its flow must be timely and in the quantities and qualities needed by the various management levels. The flow of information circulates throughout the organization in such a manner that it can bring the pieces together into a common whole, thus making the organization more responsive to outside influence and requirements. It requires, however, a significant, and in many cases an explicit, change in managerial philosophy and practice, particularly at the middle management level. In the past, the only place in the organization where any

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[1]H. A. Simon, <u>op. cit</u>., pp. 43-47.

degree of "wholeness" was felt necessary or where any attempt at coordination was made was at the top management level. The integrated systems approach will provide a new and dynamic challenge to all levels of management. As Drucker states:

> In dealing with their new tasks, the managers of the 1960's will to a large extent have to employ the same tools they are using today. But managers will also find, increasingly, that they are expected to to know, understand, and handle new concepts and tools of management. Increasingly, they will find that they are expected to use systematic methods of analysis and decision making, supplemented by new tools of communication, computation, and presentation.
> Executives can safely disregard all the fanciful talk about the computer 'replacing managers' and 'making decisions.' Manager's work, it can be said with confidence, is going to become more important and their numbers larger. But the 'management sciences'--such as operations research or decision making logic--and the new electronic tools and systems are going to make a difference, even to the manager in the small business.
> And the manager of 1970 will need all the help he can get from such new concepts and tools. For his job is going to be so complex, so big, so demanding as to require all the tools of simplification and systemization that can possibly be obtained.[1]

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[1]Peter F. Drucker, "The Next Decade in Management," Dun's Review and Modern Industry, LXXIV (Dec., 1959), 61.

CHAPTER III

CURRENT BUREAU OF YARDS AND DOCKS MANAGEMENT

Discussion of the integrated systems approach to Bureau of Yards and Docks management[1] would be meaningless without considering current management practices and information systems. These, in turn, cannot be fully evaluated without consideration of the organizational framework within which the Bureau's management take place. The need for this review holds true today even though the recent Navy-wide management study promises some reorganization of the Department of the Navy, for any revised or remodeled Bureau management system should utilize the best of what is available. Study of the current Navy organizational framework is particularly important in the case of Bureau of Yards and Docks because the Bureau is concerned with functions which have some of the most widely dispersed assignment of responsibilities of all of the Navy's business activities.[2]

The existing organization of the Department of the Navy evidences

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[1]Throughout this thesis any reference to Bureau of Yards and Docks management is intended to include the management of all levels of the total Bureau organization, i.e., the Bureau of Yards and Docks, the Bureau's field engineering offices, and the Civil Engineer Corps managed Public Works Departments at the various Naval activities.

[2]Business activities are meant to include those portions of "logistics administration and control" which deal with the acquisition, maintenance, and disposal of facilities and installations, and the equipment pertaining thereto; and those portions of the "business administration" tasks of the Navy which deal with the administrative procedures concerning facilities and installations, and the budgeting and expenditure of funds pertaining thereto. (Department of the Navy, General Order No. 5, 14 May 1959, as amended, pp. 2-3).

the bilinear concept of control over the shore establishment. The Chief of Naval Operations is responsible for the "Naval command" of the Department of the Navy, except for those areas where command functions within the "Naval command" task rest with the Commandant of the Marine Corps. The Chief of Naval Operations responsibility carries into the area of planning, forecasting, and determining requirements; coordinating and directing the efforts of the various bureaus and offices as necessary to effectuate the availability and distribution of these requirements; and issuing statements of Operation Force requirements, in terms of what is needed, where it is needed and when it is needed, to the bureaus and offices of the Navy Department, and through them to the Shore Establishment.

The Navy technical assistants (Bureau Chiefs) are responsible for immediate supervision of their own organizations including:

a. The planning and translation of approved requirements into firm procurement schedules.

b. The research in, and the development, procurement, production, utilization and distribution of equipment, material, and facilities.

c. The procurement, training, administration, assignment and utilization of personnel.

d. The operation and management of all activities assigned to them.

e. The sound and legal expenditure of funds appropriated for performance of their work, including preparation of estimates for funds required to carry out approved plans and directives.

f. Acting as technical advisers and assistants to the Secretary of the Navy, the Civilian Executive Assistants, the Chief of Naval Operations, and the Commandant of the Marine Corps in the formulation of

policies and procedures governing the administration of the Department of the Navy.[1]

Administration of the shore activities of the Navy is divided into the functions of military command and management control. Military command, exercised by the Chief of Naval Operations, is concerned with the military operation and military administration of shore activities. Management control constitutes:

> Complete management . . . of the performance of the work of shore activities . . . . the exercise of executive authority and responsibilty for the performance of the mission, tasks, and work of shore activities . . . . (including) mission planning, shore activity development, workload planning, internal organization and procedures, budgeting, accounting, staffing, and the utilization of personnel, funds, materials, and facilities. Management control also includes responsibilty for appropriate coordination and application of technical direction. This technical direction is the specialized or professional service . . . . by bureaus and offices . . . in accordance with their assigned missions . . . . Assignment of responsibilities for technical direction to bureaus and offices, other than those exercising management control, will be made only when it is determined by the Secretary of the Navy to be in the best interest of the total organization to achieve coordination or more efficient performance . . . [2]

This dichotomous situation of management and technical control presents a perplexing organizational concept. In those instances where both types of control are vested in the same Bureau, there is no problem. Such is not the case, however, when these control features are divided between different Bureaus at any one activity. This leads to the situation where the Bureau having management responsibility exercise the only real measure of control since that bureau controls the activity's funds. On the other hand, the technical bureau has responsibility for performing a particular function at the activity, but is nevertheless subject to the "appropriate coordination and application"[3] aspects of the management

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[1]Ibid., pp. 4-6.

[2]Department of the Navy, General Order No. 19, 21 May 1959, pp. 1-2.

[3]Ibid.

control bureau. In short, the favorable outcome of technical control efforts depends to a major degree on implementation by others.

Concerning the role of the Bureau of Yards and Docks in Shore Establishment Management, the Bureau, except as otherwise prescribed, is responsible for planning, development, procurement, construction, alteration, cost estimates, and inspection at all shore activities of public work's, public utilities, construction, transportation, and weight handling equipment. The Bureau is also responsible for acquisition and disposal of real estate, and the exercise of management control over Navy housing. In addition, the Bureau exercises technical direction of all housing, and the repair and upkeep of public works, public utilities, construction, transportation, and weight handling equipment, and the operating standards and procedures pertaining thereto.[1]

For the performance of its assigned tasks, the concept of Bureau organization is one of central direction through decentralized management. The Bureau of Yards and Docks exercises management control over 35 activities including Field Engineering Offices (Field Divisions, District Public Works Offices, Area Public Works Offices and Offices in Charge of Construction) and Field Activities (Public Works Centers, Public Works Transportation Centers, and others). The Bureau has technical control, within its assigned area, over all of the Naval commands within the Shore Establishment.

The Bureau's management tasks are broken down into the functional areas of planning, design, construction, maintenance, and budgeting. It is, however, noted that the only budgeting activity carried on by the field engi-

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[1]Department of the Navy Organization, NAVEXOS P-861 (June, 1962), p. II-47.

neering offices is in connection with its own internal administration.[1] Accordingly, in support of the major management functions, the Bureau's management responsibilities are performed through three basic systems: Planning, Military Construction, and Public Works. The general characteristics of each are as follows:

I. <u>The Planning System</u>

The Bureau's major responsibilities in the planning area are in support of the Navy Shore Facilities Planning and Programming System. As a management bureau, the Bureau is responsible for initiation of valid facility requirements for those activities under its management control; however, the major planning responsibilities of the Bureau of Yards and Docks are in the area of the technical services it performs for other bureaus and for the Office of the Chief of Naval Operations.

There are three ways in which the Bureau provides this technical assistance. The first is the engineering evaluation of existing assets which the Bureau performs at each Naval activity. The second is the technical assistance provided by the field engineering office to the Naval District Commandant in connection with the coordination of multiple activity facilities planning. The third is the technical assistance, including engineering comments, which the Bureau provides to the Office of the Chief of Naval Operations relative to the preparation and issue of the Military Construction Component of the Navy's Effective Program Projections.[2]

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[1]Budgets for housing activities are reviewed and commented on by the field engineering offices.

[2]The Military Construction Component of the Navy's Effective Program Projections contains the military construction programs that are being executed through and including the current fiscal year as well as those for the budget fiscal year and the ensuing four fiscal years. In addition, it also contains requirements that have not been programmed (OPNAV INSTRUCTION 11010.1D, 30 July 1962, Section 6, p. 1).

Of these three types of planning assistance, perhaps the most significant is the evaluation of existing assets. This process consists of an engineering analysis of fixed assets at each Naval activity to determine the best method of satisfying any deficiencies, and, if construction is required, the conduct of engineering studies necessary to determine the scope of required construction, rehabilitation or modernization.

The analysis is conducted by a team of engineers from the planning and maintenance divisions of the cognizant Bureau field engineering office. This team utilizes such information as may be available, including maintenance cost records and maintenance and inspection records. The actual survey includes the determination of substandard assets, whether a particular facility should be razed or repaired, and the expected remaining life of the facility after repairs. When construction is determined to be necessary, the team furnishes line item scope and engineering data to the activity Commanding Officer. The results of the survey are subject to the Commanding Officer's concurrence, or resolution at a higher level (Bureau or Chief of Naval Operations) where necessary.[1]

II <u>The Military Construction System</u>

The Bureau's responsibilities for the design and construction of all facilities for the Shore Establishment are carried out in three steps. The first occurs during the preparation of preliminary engineering studies for the various military construction line items. These studies indicate the exact scope, the detailed cost estimate, and the specifications for each line item. The second step is the preparation of construction drawings and specifications for each line item, and the third step is the

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[1] <u>Procedures for Planning Naval Shore Activities</u>, NAVDOCKS P-340, (18 April 1961), pp. 19-29.

construction of each facility. The Bureau's field engineering offices are directly responsible for each of these steps. Engineering work performed during the first two stages is carried out either by the design division of the field engineering office or by an architect-engineer under a contract administered by the field office. Construction is performed by contract except in those few instances where government forces do the work. Overall management of these three steps at the field office level is through a system which monitors the scope and the cost of each line item, and reports deviations as well as the progress of design and construction to the Bureau. Significant deviations in item scope or cost require Bureau approval or further Bureau action at the Departmental level.

III <u>The Public Works System</u>

This system is composed of three segments: Maintenance, Transportation and Public Works Cost Control. General details of each segment are as follows:

A. <u>The Maintenance Segment</u>. The basic objectives of this segment are threefold: To raise facility maintenance to a proper level, to increase the productivity of the maintenance work force, and to achieve savings in maintenance and utilities operation. To gain these objectives a process of continuous facility inspection, planning and estimating, shop scheduling, and reporting is utilized. The purpose of this approach is to perform facility maintenance on a scheduled basis thereby achieving more satisfactory maintenance, and controlled operation of the maintenance and utility services. Management reports provided by this segment are:

1. Expenditure analysis by work center (carpentry, electrical, etc.) showing material and labor costs both estimated and actual. The labor costs are further broken down to indicate those based on use of

engineering performance standards (EPS) and those based on non-EPS estimates. This report is prepared by all Naval activities and Public Works Centers.

2. Labor analysis indicating the labor used on standing job orders, on specific job orders, and on minor work authorization. Every Naval activity prepares this report by work centers. Public Works Centers prepare two labor analysis reports: One by work center, and one for each Naval activity being furnished maintenance and utility services.

3. Work center backlog broken down into the various job order classifications and showing total dollar value of backlog work. This report is prepared by Naval activities and by Public Works Centers.

Labor analysis reports prepared by each activity are retained by the Public Works Officer for local use; expenditure analysis and backlog reports are forwarded monthly to the Bureau field engineering office. The field office reviews the reports and forwards comments to the Naval activity concerned. Reports originated by the Public Works Centers are forwarded monthly to the Bureau of Yards and Docks and to the regional Bureau field engineering office. On the basis of monthly activity reports, the Bureau field engineering offices submit semiannual reports to the Bureau for all activities under their jurisdiction which have over 30 personnel in their combined maintenance and utility divisions. In general, this report indicates total public works expenditures including a breakdown of productive and overhead work, comparison of actual performance with that estimated, total work backlog, and comments concerning significant variances. The Bureau consolidates this information and forwards it to the respective management bureaus for their information.[1]

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[1]Maintenance Management of Public Works and Public Utilities, (including change No. 1, Feb., 1962), October, 1961, NAVDOCKS P-321.

B. The Transportation Segment. This portion is concerned with the operation, utilization, and maintenance of transportation and construction equipment. Each Naval activity forwards to the Bureau a semiannual report showing vehicle utilization and indicating vehicles in excess or in short supply. Consolidated reports are prepared by each Bureau field office for the area under their cognizance. This reporting procedure provides for analysis of equipment utilization compared to standard utilization factors. There is also an annual report of maintenance and operations cost for each type of equipment as well as an annual report of maintenance manpower and cost analysis which highlights those instances where maintenance labor exceeds the standard input.

From these data the Bureau is able to review the Navy-wide allocation and assignment of vehicles, the effectiveness of the transportation maintenance program, and, through the use of standard life expectancy and economic replacement tables, to forecast future new equipment requirements.[1]

C. The Public Works Cost Control Segment. Initially the purpose of this program was to integrate the budget, engineering, accounting, and management functions of maintenance into a single system. The initial effort was made in July, 1959, when the Bureau, in collaboration with the Comptroller of the Navy, received cost data for selected existing cost classifications. This information, which was sorted and compiled by the Bureau's computer installation at Port Hueneme, California, formed the basis of a tentative reporting system for Fiscal Year 1960. It was soon apparent, however, that revised Navy cost classifications were required in the public works area of accounts if any meaningful results were to be obtained. This was accomplished through the issue of additional public works cost accounts by the

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[1]Management of Transportation Equipment (Sept., 1962) NAVDOCKS P-300.

Comptroller of the Navy in March, 1960.[1]

The objective of this cost collection process was to arrive at functional norms for maintenance. In this respect, it was recognized that such norms would be affected by many factors such as wage rates, type of construction, facility condition, size, and others. The ultimate goal was to establish a direct relationship between the maintenance cost history and maintenance budgets.[2] This system of cost collection and analysis was coupled with a drive towards improved maintenance procedures through the Controlled Maintenance Program as well as more effective consolidated maintenance in those areas where Public Works Centers were approved.

Based on the 1960 expenditure accounts, Navy-wide Public Works cost data were accumulated for Fiscal Years 1961 and 1962. This information included direct labor, material, and overhead costs in the areas of transportation operation and maintenance, real property maintenance and repair, utility operations, and other miscellaneous operations and services. The most extensive coverage was in the area of real property maintenance and repair where costs were collected for over 450 expenditure accounts. The number of accounts was, however, reduced to 130 prior to Fiscal Year 1963 (Appendix A) since the Comptroller of the Navy determined that the larger number was imposing too much of a workload on the individual activities. In either event there are several noteworthy points. The costs collected are only for each major type of facility, i.e., barracks building permanent, barracks building nonpermanent, etc. The permanent and nonper-

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[1] Processing, Reporting and Analysis of Public Works Cost Data: Interim Operating Handbook (June 1960), NAVDOCKS P-344, p. 1-2.

[2] U. S. Congress, House of Representatives, Subcommittee on Defense Appropriations, Hearings on Department of Defense Appropriations for 1962, 87th. Cong., 1st. Sess., Part 2, Operations and Maintenance, pp. 410-412.

manent catagories are so general that they offer no real means of correlating the data with the specific type of construction. Furthermore, there is no means of accounting for facility age. These factors present significant limitations to the current public works cost collection system.

Within these limitations, cost control reports are prepared by the Port Hueneme computer installation based on data received from field activities and the Navy Regional Finance Offices. These reports are:

1. Quarterly reports of direct labor, material and overhead costs of transportation, utility, and maintenance operations on a Navy-wide basis summarized by management bureaus and by Naval Districts. Annual reports are prepared for each Naval activity.

2. Annual detailed listings of real property inventory and maintenance cost data for each type of facility shown in Appendix A . This information is summarized on a Navy-wide basis as well as by management bureaus. Significant data shown are unit maintenance costs, and total maintenance costs as a percentage or original cost[1] and replacement cost.

3. Annual listings of expenditures by expenditure account numbers.

4. Annual frequency distribution analyses of maintenance costs for each facility type at U. S. and non-U. S. activities.

5. Annual backlog of essential maintenance of facilities, summarized to show the backlog for each activity under the various management bureau's cognizance.[2]

In summary, the Public Works Cost Control Segment represents the

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[1]Original cost is of little significance, due to inflation.

[2]<u>Processing, Reporting and Analysis of Public Works Cost Data: Operating Handbook</u> (Oct., 1961), with changes 1-5, NAVDOCKS P-344.

beginning of a system of integrated Public Works management. To date a considerable amount of data has been collected. The Bureau's analysis of these data indicates that significant differences in maintenance costs between activities cannot be attributed to wage rates or apparently to location. Regarding type of construction, there appears to be no direct correlation between type (permanent and nonpermanent) and maintenance costs, since maintenance costs for permanent facilities are higher in some instances than for nonpermanent. One opinion advanced is that station Commanding Officers are desirous of upholding standards in permanent facilities, and will therefore want to spend more maintenance funds on the permanent buildings rather than on the nonpermanent one. It should be noted again, however, that this cost collection system does not reflect the specific types of construction nor does it account for facility age. In addition, another significant factor which has also been recognized by the Bureau, is that this system shows only what was done. There is no way of telling how much maintenance work should have been done. For these reasons the Bureau recognizes that the present cost reporting system is really not much more than an accumulation of cost data, and that it falls far short of the original objective of relating cost history to budgets.

The foregoing discussion of the Planning, Military Construction and Public Works Systems has been a general review of the major elements of the existing management and information systems within the Bureau. In summary, it is evident that current Bureau of Yards and Docks management is based primarily on furnishing technical services to the Shore Establishment of the Navy. As a consequence, while Bureau management must be responsive to Shore Establishment needs, the fruits of much of this management effort depend on its acceptance by the Shore Establishment. In the performance of its tech-

nical responsibilities the Bureau relies on three basic systems. Two of these systems, Planning and Military Construction, are related in general to the Navy's needs for additional or more modern and up-to-date facilities. The Public Works System, on the other hand, is related to the day-by-day operation and maintenance of the Naval Shore Establishment.

The Planning System, which is an outgrowth of the Bureau's participation in the Naval Shore Facilities Planning and Programming System, affords the Bureau the opportunity to provide technical assistance at the activity level and at the departmental level. Through this technical assistance, and particularly through the process of evaluating facility deficiencies, the Bureau has achieved a measure of integration between the planning and maintenance functions.

Through the Military Construction System there is a degree of integration between the engineering and construction functions. Perhaps the greatest measure of integration in the field engineering offices comes in those instances where the design and construction divisions are under a single head.

The Public Works System, although divided into three segments or subsystems, seems to promise a reasonably high degree of public works integration through the Public Works Cost Control reports. In the case of facilities maintenance, however, there are major stumbling blocks in the way of achieving the ultimate objective of relating budgets for future maintenance operations to past history. The problem of establishing the functional norms revolves about the fundamental economic and physical problem of how to collect meaningful raw data.

CHAPTER IV

AN INTEGRATED MANAGEMENT SYSTEM

The fundamental and basic step in any integrated management system is to set forth the objectives of the system. Since the Bureau of Yards and Docks is a part of the Naval Shore Establishment, the ultimate objective of any of the Bureau's management functions is to provide support for the operating forces. This is true for any part of the Naval Shore Establishment; however, in terms of everyday business activity, such an objective is too remote. For day-to-day management of a Public Works Department work center, or the Design Division of a Bureau field office, or, for that matter, of the Bureau itself, it seems that a more tangible objective must be set.

It would seem that such an objective should be related to resources, for that is what is being managed. Men, money, and material are significant to anyone, from the Chief of the Bureau down to the most junior man in the organization. The significant factor, however, is how these resources are being used. It seems reasonable to say that resources should be used in such a way as to bring the maximum overall gain to the "corporate owners"--the taxpayers. The objective of the Bureau's integrated management system is therefore considered to be the maximum utilization of resources.

To relate this objective to an integrated management system for the Bureau of Yards and Docks, there are four basic points to consider: (1) The major management functions, (2) the relationship of the total system objective to these management functions, (3) measurement of the system objective in terms of the management functions, and (4) in terms of points (1)-(3), the

management information needed at the various Bureau levels (Departmental, Field Engineering Office, and Station Public Works Department).

The major management functions are planning, design, construction, maintenance, and budgeting. The relationship of maximum resource utilization to each of these functions highlights the following basic considerations: (1) planning should insure the selection of alternatives which best meet the specific overall needs of the Navy; (2) design should insure a facility which satisfies the parameters set during the planning stage, but which will also recognize the dynamic nature of the Navy; it must also provide for effective utilization of engineering manpower; (3) construction should insure quality and financial control as well as timely beneficial occupancy by the government; (4) maintenance should insure economy and efficiency of operations, and the accumulation of critical data for management decision making; (5) budgeting should insure the use of proper job planning and control.

A major problem is that of achieving each of these functional objectives in a practical and workable manner. Analysis of the several functional objectives leads to the following five basic points:

I. Planning. The objectives of Navy planning are to determine requirements, including an evaluation of the life of the requirements, and the most cost effective way of fulfilling them. Determination of facility requirements is the line operator's prerogative, and the Bureau plays no part in this operation. An evaluation of the life of the requirement is also a line function; however, in this instance the Bureau is able to provide valuable engineering assistance. It is, however, believed that such assistance should be in more depth than is now the case.

Determination of construction requirements must consider all of the facts. In any planning situation the planner is confronted with two

basic considerations: What is the duration of the requirement, and what are the future costs of the various investment alternatives. The first point is concerned with the fact that too often where is a lack of specific attention given to the duration of a particular facility requirement. As a result, the tendency is to propose a facility which has a high degree of permanency and which minimizes maintenance costs. Although there will be times when this solution provides the best answer, it is nevertheless considered that there should be a more objective means of analyzing each planning situation to determine the best method of fulfilling the requirement. To accomplish this it is believed that the only method which will give a true picture, and at the same time be responsive to both the duration of requirement and the future cost considerations, is one based on the comparison of the lifetime costs of the investment alternatives. This will furnish a means of assessing the full effects of the decision by providing an opportunity to analyze many specific issues. Not only will it consider first cost and projected maintenance costs, but it will also demonstrate the effects of accepting a facility with a shorter lifetime. In short, it is believed that this method of planning analysis will give a truer picture of how the Navy's long-run facility requirements can best be met.

The analysis of these various points leads to several considerations. In any instance of facility planning there are two basic situations. Either a new facility is required to meet a totally new requirement, or there is need to repair or replace an existing facility. To properly analyze the first planning situation where a new facility is required, it is necessary to consider the alternatives of a facility with a high initial cost and low maintenance as opposed to one with low initial cost and higher maintenance. To accomplish this objective it is proposed that two lifetime cost estimates

be provided for each new construction situation, one for a facility with a 15 year life to replacement and a second for a facility with a 25 year life to replacement.[1] In this respect one factor becomes immediately apparent. It is necessary to arrive at some definition of 15 and 25 year construction. This would ordinarily entail detailed study of many types of building materials to arrive at specific combinations which would give economic lives of 15 and 25 years. At this point, however, this is not necessary since the objective of this paper is simply to focus attention on the fact that there is more than one way of fulfilling a facility requirement when economic life is the main consideration. Suffice it to say, therefore, that 15 year construction for a building would be equated with wood or light steel frame, dry wall interior, composition siding and 15 year built-up roofing. The 25 year alternative would be masonry, reinforced concrete, or heavier steel frame with precast concrete exterior walls, metal lath and plaster interior partitions, and 20 year built-up roofing.

Considering these alternatives and the fact that lifetime costs are involved, it also becomes apparent that such a method of analysis requires the projection of costs 25 years into the future. This is a difficult task; however, it is equally apparent that these costs cannot be ignored. They are factors which must play their part in the investment decision, and which the specific method of investment analysis must recognize.

In the second planning situation, where the alternatives are either to repair or to replace an existing facility, it is also necessary to consider all the facts. Facility replacement is a matter of economic choice, yet too

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[1]It must of course be recognized that design criteria will limit economic choice in the case of certain facilities. An example is the criteria for aircraft pavement which must conform to standards for tire pressure and wheel loading. This is not to say, however, that such criteria should not be subjected to the closest possible scrutiny.

often the justification for replacement funding hinges on the statement that the proposed new facility is a sound proposition because it will eliminate excessive maintenance costs. Excessive maintenance costs are difficult if not impossible to define within the present state of the art. Furthermore, such statements invite rebuttal because they cannot be supported with facts. As in the instance of the new construction situation, if lifetime cost estimates are prepared for the repair-replacement alternatives, it is considered that an objective means will be provided for the analysis of exact and specific requirements, both immediate and long-run.

If these principles can be accepted as valid, it would appear that the remaining question is how to analyze the various alternatives in the different planning situations. The method selected must be one which not only accounts for first cost and projected maintenance costs, but which also fulfills two essential objectives. It must be directly related to the overall system objective of maximum resource utilization, and it must account for the uncertainty which is inherent in predicting long-run requirements and cost savings.

To fulfill the objective of maximum resource utilization, it is essential for the planning studies to incorporate a yardstick or standard against which the variables can be measured. Selecting such a standard could prove to be a major problem in itself; however, it is considered that much of the difficulty can be overcome by borrowing a page from the commercial businessman's handbook. The analysis of commercial investments in fixed assets is invariably made on the basis of the financial return which may be expected from the proposed investment. This provides for the businessman the all important measure of potential profit. Although the government is not in business to make a profit, it is most certainly obligated to carry out its business

operations at the least cost to the taxpayers. Considering this fact, it would seem logical for alternative facility investments to be assessed against their respective abilities to generate enough savings to represent a reasonable return on the taxpayer's investment. Unlike the businessman who is measuring the return he expects to gain from increased profit due to expanded production facilities, the government must measure the return which comes from the lifetime savings that may be expected from one type of fixed asset investment as opposed to the alternative.

Measuring the financial return on the investment is considered an entirely acceptable approach to the management of the government's business activities. It is agreed that such a premise may not be altogether acceptable in the case of weapons system analysis since the only real payoff comes in the system's ability to deter or defeat the enemy. This, however, is not the case in the business sector of the government economy, and particularly when it comes to management's accounting for its business stewardship. In fact, it is considered that a rate of return analysis is the only appropriate measure of the effective business utilization of the resources which the taxpayer must provide.

Considering this issue as settled, it is necessary to determine an acceptable rate of return. In the business world the minimum satisfactory return is the cost of borrowed capital. Since the government is also in the business of borrowing and lending money, it is considered that the same approach would provide an economically sound basis for the analysis of government investments in fixed assets. It is therefore proposed that the government's cost of borrowed capital--in the order of 3% annually--be considered as an acceptable rate of return when measuring potential savings from

alternative facility investments.[1]

The point remaining then is to account for the uncertainty involved in long-run projections of requirements and savings. Here again a comparison may be drawn with the commercial business community. Commercial analysis of capital investments recognizes the uncertainty which is inherent in predicting future cost savings as well as the fact that requirements themselves cannot be projected into the future without some risk. Because of these factors, the astute businessman knows that it is not realistic to enter into an investment situation on the basis that future cost savings, weighted the same as present-day dollars, will counterbalance high initial costs. If nothing else, it is apparent that the cost of borrowed capital tends to reduce the value of future savings, and this is accounted for in the selection of an appropriate rate of return. It is, however, necessary to add an additional factor to account for uncertainty. What seems to be a firm requirement today may not exist in 15 years. Furthermore, although projected cost savings may seem reasonable, there is always the chance that they may be less than expected, or that they may not be realized at all. Consequently, commercial analysis of capital investments recognizes the need to discount future cost savings in order to account for risk and uncertainty, and to allow for the expected return on the capital investment.

Authorities agree that discounting alternative military projects is done for the same reason as in the private economy.[2] In the specific case of facilities there is always the likelihood that assets planned for today may not be required 15 or 25 years from now. Furthermore, the difficulty of predicting the maintenance cost savings of one alternative over the other

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[1]cf. Charles J. Hitch and Roland N. McKean, <u>The Economics of Defense in the Nuclear Age</u> (Cambridge: Harvard University Press, 1960), pp. 207-208.

[2]<u>Ibid</u>., 208.

also makes it essential to discount the future. Considering each of these factors, there appears to be no logical reason for not discounting the future when considering alternative facility investments. Failure to do so simply overlooks factors which may invalidate the entire situation.

Choosing an acceptable discount rate presents the problem of evaluating all the factors involved. How much is an error in prediction worth; what will be the effect of uncertainty? It must surely be recognized that facility investments do not usually involve excessively large sums of money. The risk is obviously not the same as for a multi-billion dollar weapon system. Furthermore, many facilities can be designed to serve varying purposes which again reduces the risk of a waning requirement, and tends to mitigate the effects of uncertainty. Considering these factors, it is proposed that the total discount (return on investment plus risk) be in the order of 6% which will allow 3% for return and about 3% for risk.[1]

To illustrate the foregoing points, a typical facility investment situation will be analyzed at a 6% discount rate.[2] The situation proposed will be one involving the proposed replacement of an existing 800 foot timber wharf.[3] The alternatives available to the planner are:

A. <u>Alternative No. 1.</u>

A new reinforced concrete wharf, 800 feet in length, with initial cost estimated to be $1,200,000. It is assumed that this

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[1]There may be those who would argue that a 3% discount for risk is excessive. This may be so; perhaps 2% would be better. It is not the writer's intention to argue this matter, however, since the only important item at this point is to "sell" a management principle.

[2]For example and explanation of discount method see Appendix B.

[3]Similiar analyses could be made of the new construction 15 and 25 year alternatives.

wharf would have a 25 year life with no substantial salvage value.[1] It is further assumed that no maintenance will be required during the first 5 years, $1,000 per year will be required from 6 to 10 years inclusive, $2,000 per year for 11 to 15 years inclusive, and $4,000 per year for 16 to 25 years inclusive.

B. Alternative No. 2.

Major repairs to the existing 800 foot timber wharf would be extensive. The cost of the repairs is estimated to be $700,000, which will provide a facility having 15 year life with no salvage value. Assumed maintenance costs for this wharf are $2,000 per year during the first five years, $6,000 per year for 6 to 10 years inclusive, and $10,000 per year for 11 to 15 years inclusive.

Through the use of a 6% discount rate, the present worth of the various cash flows for each of the alternatives can be computed. Determining the present worth of the cash flows will make the two alternatives directly comparable since it is possible to compute a single amount of money for each alternative which is equivalent to each of the two series of cash flows, and which is stated in terms of more realistic present-day dollars. This computation would give the planner a significant item of information which could be used with other factors to arrive at a final decision.

Present worth computations for the two alternatives are shown in Figures 2 and 3. Alternative No. 1, the replacement wharf, shows a present worth of $1,570,000 compared to about $1,272,000 for the second alternative. It is apparent that the better choice is to repair the existing wharf. At the same time it is interesting to note that if future costs were not discounted, the comparative lifetime costs (based on 75 years equivalent life)

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[1]Any expected salvage value must also be discounted.

of the two alternatives would be $3,765,000 for replacement and $3,950,000 for repairs. Thus, without discounting, the planner has all the ammunition he needs to make the wrong decision. Instead of extending some benefit to the taxpayers in the way of a positive gain on their investment, he would actually be penalizing them; instead of recognizing the risks and uncertainties present in forecasting, he would be blindly ignoring them. Besides these important factors, there is another significant point to be gained from sample calculations--although maintenance costs are a factor which must be considered in any facility investment situation, they do not play a significant part over a long period of time since they are so heavily discounted in later years.[1]

Yr. from Install. Date (1)	Capital Outlays Incurred (2)	Annual Maint. Costs (3)	Present Worth Factor Uniform Payment Series (4)	Present Worth Factor Single Payment (5)	Present Worth of Cash Flows (6)=(2)(5) (6)=(3)(4)(5)
	New Facility				
0	$1,200,000	--	--	--	$1,200,000
1-5		--	--	--	--
6-10		$1,000	4.212	.7473	3,336
11-15		2,000	4.212	.5584	4,704
16-25		4,000	7.360	.4173	12,285
	1st Replacement				
25	$1,200,000	--	--	.2330	279,600
26-30		--	--	--	--
31-35		1,000	4.212	.1741	733
36-40		2,000	4.212	.1301	1,095
41-50		4,000	7.360	.0972	2,862
	2nd Replacement				
50	$1,200,000	--	--	.0543	65,160
51-55		--	--	--	--
56-60		1,000	4.212	.0406	171
61-65		2,000	4.212	.0303	255
66-75		4,000	7.360	.0227	668
				Total Present Worth	$1,570,869

Note: To make the alternatives, which have different economic lives, directly comparable, it is necessary to use the least common multiple, 75 years.

Figure 2. Alternative No. 1. Present Worth Replacement Wharf.

[1]This principle would apply until the discount rate becomes very small.

Yr. from Install. Date (1)	Capital Outlays Incurred (2)	Annual Maint. Costs (3)	Present Worth Factor Uniform Payment Series (4)	Present Worth Factor Single Payment (5)	Present Worth of Cash Flows (6)=(2)(5) (6)=(3)(4)(5)
	Repair Costs				
0	$700,000	—	—	—	$ 700,000
1-5		$2,000	4.212	—	8,424
6-10		6,000	4.212	.7473	18,886
11-15		10,000	4.212	.5584	23,520
	1st Repair				
15	$700,000	—	—	.4173	292,110
16-20		2,000	4.212	.4173	3,540
21-25		6,000	4.212	.3118	7,880
26-30		10,000	4.212	.2330	9,814
	2nd Repair				
30	$700,000	—	—	.1741	121,870
31-35		2,000	4.212	.1741	1,477
36-40		6,000	4.212	.1301	3,288
41-45		10,000	4.212	.0972	4,094
	3rd Repair				
45	$700,000	—	—	.0727	50,890
46-50		2,000	4.212	.0727	617
51-55		6,000	4.212	.0543	1,372
56-60		10,000	4.212	.0406	1,710
	4th Repair				
60	$700,000	—	—	.0303	21,210
61-65		2,000	4.212	.0303	257
66-70		6,000	4.212	.0227	564
71-75		10,000	4.212	.0169	712
				Total Present Worth	$1,272,135

Note: To make the alternatives, which have different economic lives, directly comparable, it is necessary to use the least common multiple, 75 years.

Figure 3. Alternative No. 2. Present Worth of Repaired Wharf

The values of discount calculations to the planner are apparent. No longer is the planner faced with trying to make a guesswork comparison of unlike objects since they have been converted to the same present-day dollar base. No longer must the planner make decisions based on half the information; it is now possible to assess the total lifetime cost of each alternative in a realistic manner. It is also readily possible to see the effect of accepting a facility with a lower first cost and higher maintenance costs. In short, it is believed that this method of analyzing requirements for Navy

facilities offers the planner everything he needs to make a completely realistic and objective decision.

Possible gains to the Bureau and to the Navy from this approach to facility planning are many. From the standpoint of the Bureau of Yards and Docks this method of planning analysis offers a means for achieving more meaningful integration between planning, design and maintenance since each of these functions plays a vital part in the investment analysis. Design and maintenance engineers must provide estimates of first cost and maintenance costs respectively. Both must collaborate in deciding what type of construction would best be used to attain a particular economic life. The planning engineer, in turn, should coordinate the overall analysis and be responsible for preparing final recommendations.

There is, however, more to be gained from this method. Analysis of individual situations should be prepared by the Bureau's field engineering offices and forwarded to the Bureau. A summary of these analyses should then be compiled and forwarded by the Bureau to the Office of the Chief of Naval Operations. It is considered that the availability of such information would provide a significant adjunct to the Navy's shore facility planning system since it would permit high-level review of specific requirements, their duration, and their cost-effective relationships. The area of facility requirements is one portion of the budget where an effective system of inter-Navy economic analysis would be beneficial. It would be possible not only to make trade-offs between new construction projects or between repair-replacement alternatives, but also between the two. To achieve the best possible solution to the Navy's chronic problem of too many facility requirements but too few dollars, there must be a means for objectively analyzing all possible alternatives. It is considered that the foregoing method

offers this opportunity.

II <u>Design</u>. Maximum resource utilization is again the primary objective. In the design of a particular facility this objective can be achieved if the design is one which provides for future flexibility, and if it is one which is achieved through proper utilization of the engineering talent available in the Bureau's field engineering offices.

Considering the first point, it is apparent that decisions made by the planner will largely govern the basis of facility design. This is consistent with the fact that the designer participated in the planning function through his collaboration with the maintenance engineer in the selection of a type of construction that would best suit the requirement. Although this predesign decision has been made, the designer must not allow his imagination to become stagnant. Too often when a requirement comes up for a particular facility--say a barracks building--the designer is inclined to fall back on previous designs or on Bureau standard drawings and turn-out, in an almost mechanical fashion, a carbon copy of his reference.

The designer must remember that neither the Navy nor its requirements are static. What the architect considers as a barracks today may become a training building 15 years hence. Changes such as these can be economically accomplished if the original design is flexible. As an example, in administrative facilities it would seem that thought could be given to a modular layout that could be economically adapted to varying uses over the years. Such a facility would be one with a lightweight exterior wall and roof design, with a completely open interior, a raised floor with a modular grid of electrical conduit beneath the floor, and provision for light weight, easily moved, yet structurally sound, interior partitions. In this respect, it is interesting to note that one corporation has even

omitted the interior partitions in its main office building. Executives working in the building cite the greatly improved communications resulting from such a facility. The point to be made however, is that such facilities are flexible; they recognize changing times; they recognize that planning is not infallible.

It is contended that the design of Navy facilities should incorporate these same general principles. Navy designs have been critized at times for being too massive--for producing concrete mausoleums. In the past the argument in rebuttal has always been the desire to minimize maintenance costs through more permanent type construction; however, management's thinking is beginning to change. The Chief of the Bureau recently noted that there will be times when monumental-type buildings will be needed for long-term use; however, if the need is for a building to last five or ten years, then this is what must be designed.[1] It is the writer's contention that the discount method of analyzing lifetime costs will purposely focus attention on facility life, but, more importantly, it will give a factual and realistic basis for design.

No generalized conclusions can be drawn about the results which may be expected from discount analysis. No one can say that 15-year construction will always be the cheaper alternative, nor can this be said about the 25-year type. It can be said, however, that whichever alternative is cheaper, it will not become apparent through guesswork. It can also be said that there is no justification for an undue obsession with maintenance costs. The discount method does prove one thing; maintenance costs are not significant to the investment decision unless they are very high in the immediate

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[1]Address by Rear Admiral Peter Corradi, CEC, USN, Chief of the Bureau of Yards and Docks to the Engineering Division Director's Conference held in the Bureau, 9-13 July 1962.

future (the more certain future), or unless the first costs of the two alternatives are very nearly the same. If designers can produce a 25-year low maintenance product which has a first cost about equal to the 15-year alternative, then the taxpayers have received a real gain.

It is therefore proposed that there be a widespread trend toward the flexible type of facility design, and toward the use of lighter building materials. If this results in low cost 25-year facilities, so much the better. On the other hand, if it means 15-year facilities with increased maintenance costs, there should be no cause for alarm; costs that are projected very far into the future are discounted so heavily that they will not influence total lifetime costs to any significant degree. It is the total lifetime, including its present-worth assessment of costs and its need for long-run flexibility, that should be uppermost in the designer's mind.

The second aspect of facility design which will be analyzed is the subject of the utilization of engineering personnel. Current practice in the Bureau's field engineering offices is to use commercial architect-engineer firms as design agencies under contract to the government. Engineers in the field office design divisions are responsible for reviewing the architect-engineer's work, and for handling the day-by-day technical details related to the administration of the contract with the architect-engineer. The use of architect-engineer firms has the advantage of providing an additional work force to handle peak loads; however, their widespread use fails to maximize the available "in-house" engineering talent. The Chief of the Bureau has recognized this fact and has stated, "My personal conviction (is) that <u>we must do more of our engineering design with our own forces</u>. This is easy to say, and we have been saying it, perhaps too long.

Now I want to get started doing it."[1] It is contended that the most effective way to get such a program started is to institute a policy of using at least 50% (workload permitting) of the engineers on tasks which involve actual design.

This problem of engineering manpower utilization must not overlook the need to approach any facility design situation with the objective of achieving a well integrated design. Such a design is one which meets the broad precepts laid down during planning, including the need for adherence to the principles of long-run flexibility and attention to long-run costs. The design, however, must not incorporate any features which would cause construction or maintenance difficulties. These are familiar platitudes; they would invoke everyone's agreement, but quicken no one's pulse. Yet it is a fact that such designs are what must be achieved. Can these principles be made more viable; can they become more meaningful through the purposeful use of engineers as engineers; can they be realized more effectively through improved management techniques? It is the writer's contention that these objectives can be met, but what is needed is a fresh approach.

Such an approach must be one which looks at the objective and the tools available for its achievement. The objective is maximum utilization of resources--manpower, materials, and money. Inherent in this goal are the principles of design flexibility and integration. The tools available for the achievement of these goals are the engineers in the field engineering offices and the management of their efforts. Design divisions are now organized functionally, that is, by functional branches consisting of mechanical engineers, civil engineers, electrical engineers, and so forth. Although there is a distinct line of demarkation between the various functional

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[1] _Ibid._

branches, it is apparent that considerable coordination must be achieved between them if the final facility design is to be free from errors. This coordination is now being achieved; however, it is considered that too much of the coordination comes the hard way, and when it is finally achieved in one set of design plans, much of the same hard road must be traveled for the next design. That the road to coordination is difficult is due to the fact that engineers are organized by their individual functions, they are managed by these same functions, and they are taught to think basically within these same functional boundaries. Although experience will soften these boundaries, and although some engineers are more easily able to grasp the overall design perspective, engineering is nevertheless one field where it is all too easy to become overly specialized.

Another factor which makes the road to coordination difficult is the simple mundane aspect of physical separation. In a large engineering organization the architects may be several hundred feet removed from the electrical engineers. Human nature being what it is, the easiest way to coordinate is to remove physical barriers and physical separation. Perhaps this is why the corporation previously mentioned chose to put all management from the president on down in one single room.

Considering each of these factors together with the recognized objective of doing more design with "in-house" talent, it would seem that the best way to approach the problem would be to reorganize those engineers who will be doing actual design work into groups or teams made up of engineers from each of the functional specialities, with each team headed by a leader. Each team would then be assigned a specific type of facility, such as administrative, personnel, industrial, and so forth, and would be responsible for the complete and fully integrated design of the assigned facility

type. It is contended that through such an approach it would be possible to achieve physical coordination and integration. Furthermore, these engineers will have the opportunity to perform as a professional team. This will not only provide a means for integration, but it will also offer the opportunity for developing an elite group of team leaders who should be the natural candidates for future design division directors.

To achieve full and complete integration, however, there is another aspect which must be recognized. The benefits of complete organizational integration and the achievement of fully integrated designs can come only through the use of maintenance and construction engineers as engineering consultants. They should be assigned as consultants to a particular engineering team, and should participate in predesign conferences and in the periodic review of the design plans and specifications with a view towards removing any maintenance and construction problems before they arise in the field. It must be recognized, however, that using maintenance and construction engineers in this capacity is nothing new. It has been tried before, but its success has been questionable. It is contended that much of the problem lies with those who directly manage these several groups of engineers. A failing of many professional men is their tendency toward professional jealousy. Each guards his own specialty and resents an "outsiders" comments. It is contended that the best way to overcome these tendencies and to achieve maximum integration is for top management to purposely organize and utilize subordinates in such a way that they become members of closely integrated teams with all members working towards a common team goal.

In line with the above factors, it is considered that facility design must be approached in a new and fresh manner in order to produce the integrated and flexible designs that are needed to meet the needs of a

dynamic Navy. It is contended that the fresh approach is one which must promote the use of engineers as engineers, and which will organize the engineering effort in such a way that meaningful and effective integration of facility designs will result. These objectives can be met if the team approach to engineering is utilized. The teams, together with maintenance and construction consultation, must be held responsible for complete facility design. It is believed that such an approach will not only produce integrated designs but it will also go a long way towards the achievement of an integrated management perspective. It is further believed that using engineers in this manner will capitalize on their talents, instill in each individual a sense of personal satisfaction, and enhance his professional standing in the engineering community.

III Construction. Maximum utilization of resources during this phase of facility management comes from quality and financial control and timely completion of construction. These are items which the Resident Officer in Charge of Construction must insure through proper administration of the construction contract.

Two facets of contract administration which seem to give the most trouble in the areas of quality and financial control are the problems of insuring contract compliance through proper inspection of the contractor's work and of contract change orders. The first item, proper job inspection, can be assured only through the employment of a well trained force of inspectors. This is quite obvious, but it is also quite obvious that the general proficiency of some of the Navy's construction contract inspectors is lower than desired. This is perhaps more a fault of the system than of the men themselves. The standard civil service job description for a GS-7

General Inspector (which is by far the most prevalent grade and job title) would indicate to the uninitiated that the holder of the job is capable of conducting a 100% thorough inspection of any and all phases of facility construction. If nothing else, this would require intimate knowledge of not only all the aspects of the particular contract plans and specifications, but also of many, many federal and military standard specifications. Either the inspector in question already has such knowledge or he must have the incentive to gain the knowledge. In the writer's opinion very few GS-7 inspectors have either qualities.

Thousands of words have been written on the subject of money and motivation. Arguments concerning the effect of wages on employee motivation range over the entire spectrum. It is not this writer's intention to enter into the argument. Suffice it to say that personal experience indicates that attempts to hire "the" inspector that everyone wants are not very successful at a GS-7 grade level. Of course it is not possible just to simply promote all inspectors to the GS-9 level; furthermore, this would not solve all the problems.

In addition to the problem involved with a basic lack of motivation, there is also another significant factor involved in the use of GS-7 inspectors. Their abilities and qualities, or lack thereof, become as readily apparent to the contractor as they do to the inspector's supervisors. If a contractor is inclined to shave a few corners to save himself a dollar or two, he can soon find the times and places to do it. In other words, an inspector who cannot fully and completely represent the government is more of a liability than not having an inspector at all. If an inspector, through ignorance, allows a contractor to proceed with defective work, it becomes awkward, at the least, to have the defective work torn out and re-

placed when (if ever) it is finally discovered.

To remedy these problems it is proposed that a system be instituted of reducing the number of GS-7 inspectors through normal attrition and replacing them with a smaller number of GS-11 Construction Engineers. It is considered that this will accomplish two things. It will put a properly motivated employee out on the job where it counts. This motivation comes not only from remuneration, but also from an engineer's appreciation for a job which conforms to plans and specifications because he has a better understanding of the "why" behind the specifications. Secondly, the government is being represented by a person who is better able to command the attention of the contractor.

It is recognized that such a policy could not be followed Navy-wide. There will always be construction at remote locations where the level of activity would not justify a full-time engineer. GS-7 inspection of construction at such locations should, however, be supplemented by periodic visits by construction engineers who would spend enough time at the job site to conduct a thorough review of the work, and discuss all discrepancies, no matter how minor, with the inspector.

It is to be noted that no hard and fast rule can be established for how many GS-7 inspectors could be replaced by one GS-11 engineer; however, based on personal experience, it is considered that one well qualified GS-11 engineer can do the work of four GS-7 general inspectors. Regardless of the ratio, however, the point to be made is that more use should be made of engineers who by their basic training and motivation are better qualified to represent and protect the government's interests.

The second problem, involving contract change orders, can be overcome to a major degree if the facility design is fully integrated. Design errors or omissions can result in expensive construction contract

change orders, and it is this reason which prompts the need for a construction engineer review of the design plans and specifications before they are released for bidding. This review should also include an opportunity for the construction engineer attached to the resident construction office to examine the plans and specifications since he would be more familiar with conditions at the work site which may lead to change orders. In fact, these engineers should be consulted in the early stages of design in order to avoid last minute design changes. Thus, this is another area where it is believed that the services of an experienced field engineer would do much to insure the successful completion of a well engineered and well constructed facility.

Concerning the final aspect, timely completion of construction, it is well to spend a moment on why the need for timely completion and why it is such a problem. If the facility being constructed is in direct support of a high priority weapon system, the need for timely completion of construction is apparent. Such is not always the case, however, when the facility is an administration building, a barracks, a chapel, or any of the many general purpose facilities. If this is the case, why the concern? The concern is the fact that, as constructors, the Bureau's field engineering offices and the subordinate resident construction offices have an obligation to deliver to the customer the facility when it was promised. Even though the item in question may not be a high priority missile assembly building there has nevertheless been a considerable number of manhours that have gone into justifying the project as an urgent requirement, and a considerable amount of local station planning that has gone into scheduling the moving into the facility as well as other related details. These may seem to be minor points and perhaps they are--to everyone, that is, except the prospective user of the facility.

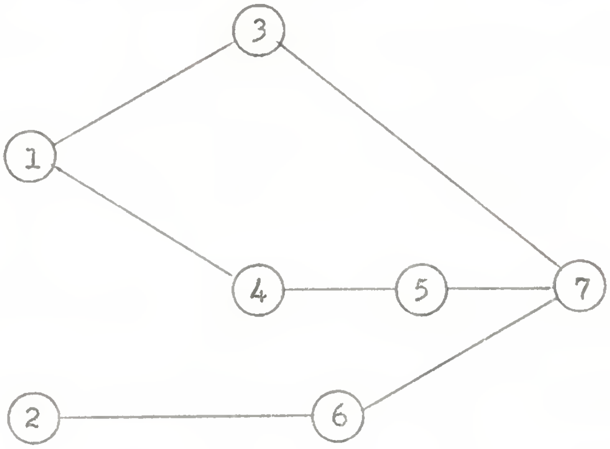
If it can be argued that customer satisfaction is an underlying motive in any organization (and it certainly must be in a service organization such as the Bureau), then these points are more than just minor. Unfortunately customer satisfaction is all too easy to overlook in the day-to-day problems of management. This is perhaps more the case in a bureaucratic organization where customer satisfaction cannot be so readily equated with organizational success. It cannot be denied, however, that this satisfaction is a significant factor in Bureau management, and it therefore seems logical to state that the Bureau should take all reasonable measures to insure that facilities are completed within the time allowed by the construction contract.

The reason why the time element is so difficult to enforce is not due to the type of contract nor due to the type of contract administration. The standard Navy construction contract provides for time extensions due to unforeseen conditions, government delays, or acts of God. In any of these general instances it certainly cannot be denied that the contractor is entitled to a time extension. Neither can contract administration be entirely blamed for the difficulty, although some people, including the writer, long felt this was the case. There would be times when it was apparent that the work was behind schedule, but regardless of the number of conferences with the contractor little action would be taken. This was so simply because the contractor knew that rarely is any contract completed without a change order. Once a change order was issued, the contractor knew he would have a solid legal basis for requesting a time extension with enough extra time "buried" in his request to account for his past slowness. Despite recommendations to the contrary, in almost every case the authorities responsible for final approval of the change order would grant the time extension as requested.

In reviewing past experience, it is apparent that the difficulty was not due to the type of contract nor to the contract administration, but rather to the fact that rarely was there any means available for the direct measurement of exactly how much a specific change order or government action affected the overall contract completion. It was felt that better prejob planning on the government's part would help to overcome the difficulty. Considerable precontract effort was spent therefore in reviewing the circumstances surrounding the job to determine how the government could assist the contractor to complete the work on schedule. One overriding factor, however, always presented a problem. The government is not in business to tell a contractor how to manage his work; consequently, any improvement which would arise from these efforts depended strictly on the contractor's willingness to cooperate. Even though this willingness was present, it still did not solve the basic issue because a change order would automatically negate all previous benefits which the government may have gained from attempts to cajole the contractor into keeping on schedule. As soon as a change order was issued, the contractor would include enough days in his time request to make up for the past delays he may have had. Government attempts to eliminate the "extra" days, although sometimes successful, were not always so because of the difficulty of assessing the exact effect of the particular change order on the overall job and its many parts. Thus again the issue reduces to one of being able to measure time delays.

Problems such as those described above need exist no longer. Management techniques such as the Program Evaluation and Review Technique (PERT) or the Critical Path Method (CPM) now make it possible to schedule a complex job including all of the many related procurement and review

actions, and to mathematically determine the particular series of job events which constitute the so-called critical path. These job events are those whose delay would delay completion of the entire job. The benefit to be gained from this method of job scheduling is that it becomes possible to assess any change order or any other factor which may have an inherent delay factor and determine whether or not this delay will effect the overall job.



Operation	Estimated Time	Start Early	Start Late	Finish Early	Finish Late	Float Total	Float Free	Critical Operation
1	5	0	8	5	13	8	0	
2	15	0	0	15	15	0	0	*
3	12	5	13	17	25	8	8	
4	6	5	15	11	21	10	0	
5	4	11	21	15	25	10	10	
6	10	15	15	25	25	0	0	*
7	9	25	25	34	34	0	0	*

Figure No. 4. Critical Path Network

This can be demonstrated by the simple Critical Path Method example shown in Figure No. 4 above. This job can be divided into seven tasks whose interrelationships are shown in the network. The contractor who will perform these tasks arrives at an estimate of how much time will be required for each individual operation such as five days for operation one and 15 days for operation two. From this information the earliest start

and finish times may be determined for each operation. For example, operation one must start at the time of contract award, and it requires five days to complete, thus its earliest finish time is five days. On the other hand, operation four cannot start until operation one is completed. The earliest operation four can start is the same as the earliest time which operation one can finish. The six days which operation four requires results in an earliest finish time for operation four of 11 days. The same type of analysis can be applied in reverse to determine the latest finish and start times. For example, the latest that operation seven can finish is 34 days. Since it requires nine days to complete this operation, its latest start time is on the 25th day.

The next operation, determining float times, is most important because it forms the basis for future actions and decisions. Total float is a measure of the amount of leeway in a particular operation. Within this amount of time, an operation may take longer to perform than estimated, or may start at a date later than its earliest start date without effecting the overall job. For instance, operation four can be delayed 10 days without effecting the total job completion; however, operation two cannot be delayed even one day without delaying the entire project. Free float is another measure of operational leeway; it is the difference between the earliest finish date of the particular operation and the earliest start dates of directly following operations. Free float indicates the leeway within which any variation effects neither the total job nor following operations. For instance, operation three can be delayed up to eight days without effecting anything else.

Examination of Figure No. 4 will reveal that operations two, six, and seven have zero total float. These are the operations which are critical

and two-six-seven becomes the critical path, the path along which no delay can be tolerated. Whatever delay does occur along this path extends the total job completion by the same amount. From this example it is also apparent that a change order involving operation three would not be the cause for any time extension to the contract unless the delay were greater than eight days. Could there be a better means of arbitrating contract time extensions?

It is therefore proposed that construction contracts (at least those exceeding $500,000) have this feature incorporated into the contract terms by requiring the contractor to submit with his bid a Critical Path Method network, with the understanding that the contractor's network would be used for the determination of all time extensions regardless of the cause. Not only will this procedure improve an important aspect of governmental contract administration, but it will also provide a positive basis for keeping the prospective using agency informed of construction progress and the expected date when the facility will be available for use.

The foregoing procedures, use of construction engineers and use of the Critical Path Method of controlling time extensions, will help achieve the overall system objective of maximizing resource utilization. This will come about through the effective use of engineers to achieve the quality of construction which the government has paid for, and through an effective means of achieving timely support of urgent facility requirements throughout the Navy.

IV. Maintenance. In a great many respects maintenance is the key to the integrated management system since it provides much of the essential feedback in the system. Previous discussion of the discount method of analyzing investment situations demonstrated one essential fact

concerning maintenance; it is significant to projected lifetime costs but, generally, only in the near future. This, however, should not be thought of as an excuse for taking maintenance management lightly. To the contrary, it lends even greater emphasis to the need for effective management since the entire basis of discount analysis and of more economical first cost is the fact that somewhat higher maintenance costs may be expected. The significance of this point is that even better maintenance management is needed. This must be achieved through a system which seeks to minimize maintenance costs.

There are two other significant factors concerning the relationship of maintenance to discount analysis. One of the essential elements in this method of analysis is to account for uncertainty, and a major factor in this regard is the matter of future maintenance costs. If their uncertainty could be removed, it would be possible to use a lower discount rate which in turn may mean the final selection of a different course of action. For instance, in the previous example of the two wharfs, if the total discount could be lowered to 4% (3% for return and 1% for risk) the lifetime cost for Alternative No. 1 would be $1,860,000 and for Alternative No. 2, $1,620,000, as compared to the 6% discounted costs of $1,570,000 and $1,272,000 respectively. Although the second alternative is still the better choice, it is apparent that the difference between the two has decreased by about $60,000 through a decrease in the discount rate. If the investment situation had been one in which the first costs of the two alternatives were more nearly equal, the lower discount rate could have meant the 25-year alternative would be the better choice. Thus by removing uncertainty from the situation, it may be possible in some instances to have more permanent construction at essentially the same lifetime cost.

The second important relationship between maintenance and discount analysis is the fact that if it were possible to establish acceptable levels of maintenance, within which continued use of the facility would be economically justified, it would then be possible to say that whenever maintenance costs consistentaly exceeded the acceptable level, the facility should be either repaired or replaced. In fact, it should eventually be possible to predict these requirements by analyzing the trends of actual costs as compared to standard.

Considering the above points (better maintenance management, the need to reduce uncertainty, and the need to be able to predict requirements) it becomes apparent that what is required is a system of maintenance standards or norms which will indicate the acceptable level of maintenance for a particular type of facility at a particular point in time. As previously discussed in Chapter III the Bureau currently has underway a program for the establishment of such norms, although the objective has been to develop a means of forecasting budget requirements. It is now apparent, however, that such standards will have applications other than budgeting.

There are two significant points concerning the establishment of maintenance standards which warrant further consideration. For standards to be of any value they must recognize the fact that facility age and specific type of construction are variables which simply cannot be overlooked. This is true regardless of the initial effort it takes to accumulate data along these lines. To assume that maintenance requirements or levels will be the same after 20 years of usage is trying to oversimplify the problem to the point where the results will be meaningless. It is likewise a gross oversimplification to attempt to establish norms without recognizing the fact that different building materials have varying maintenance requirements.

Such requirements, however, cannot be recognized through the accumulation of data by the broad catagories of permanent and nonpermanent construction. This is not to say that the Bureau is unaware of these facts. To the contrary, as previously stated, personnel involved in these studies recognize the many variables involved as well as the need to collect the additional data necessary to account for all such items.

As also previously stated, the current problem which the Bureau faces in its task of establishing maintenance standards is the method of data collection which is necessary to establish standards. Attempts to collect detailed data were thwarted by the Naval Comptroller's decision that such detailed data collection imposed an excessive workload on field activities. It is interesting to note at the same time that this workload did not include the accumulation of information which accounted for the essential factors of facility age and specific type of construction; thus data collection is required in even greater detail than before. Recognizing these facts it would appear that perhaps another approach to the problem is necessary. Such an approach must be one which is compatible with reasonable economic and physical constraints. A proposed method, which it is believed will meet the various requirements, is outlined as follows:

A. An essential prerequisite to the establishment of standards is to define the parameters within which such a system of standards will operate. These parameters must deal with specific types of facility construction, facility age, and maintenance areas within which standards will be set. The first item which deals with specific types of construction involves major considerations and more than almost casual mention is beyond the scope of this paper. It is, however, apparent that for buildings one must consider specific types of structural framing and the various types of interior and

exterior materials. Similiar considerations would be necessary for other types of facilities. Relative to the age factor, it would seem logical to assume that maintenance levels could be established which would be applicable to a particular time range. For example, maintenance requirements could be thought of as being essentially constant within any particular range such as 0-2 years, 3-5 years, 5-10 years and so forth. This of course would be subject to verification. Relative to the final item, which concerns itself with the maintenance areas in which standards should be set, it would seem that perhaps the task of setting standards could be better accomplished if it were approached in a more incremental fashion. Perhaps such an approach would consist of surveying the larger Naval activities to determine major types of workloads by work centers. These data could then be used as starting points for standard setting, since it would seem that the areas in which the most money is being spent are those which should first be brought under control.

B. After these parameters have been defined, data collection should be undertaken at selected activities which are large enough to encompass a representative sample of facility types, construction types, and age groups in those areas where standards would first be set. Public Works Centers and the larger Naval activities would seem to offer an ideal choice. Data collection should proceed on the basis of 100% inspection and evaluation, and should seek to determine not only what the level of maintenance has been within budget limitations, but also what the levels should be. The data collection should be undertaken by selected teams of experienced maintenance engineers and inspectors who would be able to reach sound conclusions, since considerable judgment would be involved. It is noted that a significant advantage of this method of data collection is that the entire operation would be under Bureau control rather than being conducted on a Navy-wide

basis which is difficult to control and administer.

C. The data collected from the survey of Public Works Centers would require considerable analysis and correlation prior to the publication of even tentative standards since it would be necessary to determine significant variances between activities, and calculate appropriate weighting factors. Included in this analysis should be the consideration of establishing minimum cost standards. For example, in areas of routine maintenance, such as the interior painting of buildings, the objective is to minimize total costs. In this respect there are two alternatives to be considered, namely, to repaint the entire interior of the building at one time, or to repaint individual areas on an as needed basis. The costs to be minimized are: (1) the cost of repainting individual areas of the building according to their varying usage factors, (2) the cost of repainting the interior of the entire facility on a regularly scheduled basis, (3) the value of old paint life wasted when covered during routine scheduled maintenance, and (4) fixed costs. It is apparent that many variables exist in even such a simple example; however, for facilities such as administrative buildings, it is considered that from the previous survey of Public Works Centers and major Naval activities, standards could be determined for the scheduled repainting of public areas and office areas. For example, it may be determined that public areas should be repainted every three years and office areas every five years. From the plans of several typical administration buildings, an average ratio of public areas to administrative areas could be determined. From this information it would appear that analysis would reveal which of the two alternative methods of repainting the interiors of administrative facilities produces the lower long-run cost over the life of the facility. Similiar analyses could be conducted in other areas where repetitive type

maintenance is experienced; i.e., servicing unit heaters, replacing light bulbs, and so forth. It is considered that guidelines for studies such as these could be provided by the Bureau to the field engineering offices who would prepare analyses for individual Naval activities under their jurisdiction.

D. Based on the data collected during the previously mentioned surveys, and their subsequent analysis, it is considered that tentative standards could be established for use at selected pilot installations. Results of the pilot installation studies would permit further review and analysis of the standards and the data collection system necessary to support their use on a Navy-wide basis.

From the preceding discussion it is obvious that maintenance standards cannot be set overnight. It is also apparent that establishing standards may have to be done on a painstaking basis; however, it is considered that the task can be accomplished if the areas where standards should be set are defined, a plan is drawn up, and milestones established. It is necessary, however, to collect and analyze data in far greater detail than is now being done. Furthermore, the problem of detailed Navy-wide data collection will come up again when performance measurement against the standards becomes effective; however, if the standards are established, and their use demonstrated at selected pilot installations it should be easier to gain top management endorsement. In this respect, as with most management controls, the use of maintenance standards will have to be sold to top management.

This sales job should not be too difficult once standards are established, because their availability would put a real measure of control in the expenditure of maintenance dollars, and would also offer an intelligent

basis for budgeting. Of equal significance is the fact that the availability of standards which are directly related to facility age and to specific types of construction materials would provide a meaningful basis for predicting the need for major repair or replacement funding as well as a basis for the evaluation of different building materials. In addition, there would be a means of predicting the long-run cost of various types of construction with a greater degree of certainty. This could possibly be the means for demonstrating the true economic advantage of more permanent-type construction (which has lower maintenance costs) through the use of lower discount rates. It would seem that there is much to be gained from the effort.

V. Budgeting. It is readily apparent that the availability of maintenance standards would provide a means whereby the Bureau could furnish considerable assistance to management bureaus in the formulation of annual budget requests since it would be possible to directly relate standard maintenance requirements to required funding levels. Another and even more significant point is the fact that the only time the budget commands any attention is once each year when the time comes to prepare the budget request for the following fiscal year. It is worthy to note that if maintenance standards were used in the formulation of the budget, then the budget itself would become a master standard against which the entire Public Works Department could be measured. It is thus considered that the relationship between maintenance standards and budgeting is more than just a means of budget formulation. Standards would also provide an objective means for the appraisal of efficient performance, thus making the budget a tool for performance evaluation and control rather than merely an annual vehicle for obtaining appropriations.

From the foregoing general analysis of the Bureau's major management functions, it is possible to summarize the concept of the integrated management system. There is a logical and essential horizontal flow of information between the various Bureau functions. From planning comes the economic data upon which investment decisions are made. These decisions, however, are influenced by feedback from the design function relative to the first cost of various facility types and from the maintenance function relative to projected maintenance costs. The final investment decision then becomes the framework for facility design which, in turn, must incorporate maximum flexibility and feedback from maintenance and construction. Maintenance and construction feedback is accomplished through the efforts of maintenance and construction engineer consultants to the design team of engineers; the purpose of the feedback to design is to benefit from previous maintenance and construction experience and avoid repeating the same mistakes twice. Final design plans and specifications become the basis for facility construction. Completed construction is, of course, the source of a physical addition to the activity's plant account as well as a source of "as-built" construction plans which are necessary to future maintenance and repair. Maintenance becomes the final element in the closed loop, since maintenance activities, which are based on the use of standard maintenance factors, become the source of budget, planning, and design information. In addition to these information flows, there is an element of feedback to maintenance which may be identified as budgetary control measures.

There is also an essential vertical flow of information between the various Bureau levels. At each Naval activity, the Public Works Officer will use the budget and maintenance standards together with labor, material,

and expenditure analyses as means of measuring and controlling efficiency, planning workload and manpower schedules, and planning future budget requirements. The Bureau's field engineering offices will employ maintenance cost data from the various activities in the economic analysis of new construction and repair-replacement alternatives. These same data will also serve as a means for continued technical assistance by the field engineering office to the activity Public Works Officer. From the computer installation at Port Hueneme, the flow of data to the Bureau will be much the same as now being furnished except that after maintenance standards are established, the cost reports should be modified to indicate exceptions to standards.[1] Summaries of detailed maintenance data received by the Bureau would be the basis for review of standards as well as a means of reporting on Bureau performance to higher authorities. In addition to public works cost data, the Bureau should also be furnished summaries of alternative economic cost analyses which have been completed by the field engineering offices. These data would serve as the basis for a Bureau prepared summary of Navy-wide alternative cost studies for use by Navy management in determining program requirements.

Little has been said in this chapter concerning the use of computers in the Bureau's management. This has been done so with a purpose because in the final analysis a computer is only a mechanized tool for processing data. The heart of the system lies in the analysis of management information requirements. It is, however, apparent that computers afford the ability for improved data collection and processing. Mechanization of the Bureau's information systems beyond that already in effect would require

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[1]Relative to public works cost reporting it would appear that reports required by NAVDOCKS P-321 and NAVDOCKS P-344 could be consolidated.

further analysis; however, it would seem that the present degree of information automation is satisfactory until such time as wide scale use of maintenance standard reporting is in effect.

CHAPTER V

CONCLUSIONS

The foregoing discussion has been aimed at reviewing the general outline and concept of a management system which, it is believed, would be responsive to the changing needs of the Navy and of the Bureau of Yards and Docks. The objective of the proposed system is the maximum utilization of resources. It is felt that this objective represents a tangible goal for all management levels.

Although it can be argued that current Bureau management has the same objective, it is this writer's opinion that such a goal can never be completely attained without a fully integrated approach to management. Day-by-day management of a public works department maintenance program is important; however, this activity is no less essential than other facets of Bureau management. The time is past for designers to be worried only about design problems and construction engineers to be worried only about their problems. It is recognized that this tendency is perhaps most pronounced at the middle management level where it is all too easy to become so preoccupied with today's problems and decisions that other and perhaps broader aspects of management are overlooked. It is therefore believed that what is needed is a management system which purposely orients all levels of the organization towards a common goal. If the merits of such an approach can be accepted, it would seem that the only question is, will it work?

As in many cases, where there is a will there is a way. With top management's blessing and a feasible plan to work from, an integrated system can be instituted. Integral parts of the plan would be greater Bureau participation in shore facilities planning, a positive trend toward the development of an approach to design which would be based on lowest lifetime cost, improved control over the quality and timely completion of facility construction, the institution of standardized maintenance procedures, and the purposeful use of the maintenance budget as a control measure. Each of these elements is an important portion of the integrated management concept; however, caution should be exercised lest any one of these items become the sole aim of the program.

It is considered that there are many benefits to be gained from an integrated approach to the management of the Bureau of Yards and Docks. For many years Navy management has attempted to obtain additional military construction funding since it has realized that after facility requirements, which support top priority programs, have been accounted for, precious little of the military construction program ceiling was left for less urgent items such as barracks, utility replacements, chapels, and other similiar projects which are of major importance to the Navy, yet cannot take precedence over POLARIS and other high priority programs. In the light of this situation it would seem that a system for objectively analyzing alternative costs would be beneficial in stretching the dollar further.

The dollar to be stretched is also the one of tomorrow. Facility design must recognize this by providing a facility which is flexible and can be economically adapted to tomorrow's needs. The design effort, however, must be undertaken in such a way that the taxpayers reap the maximum

gain from personnel who are on the government payroll. The benefits of the system also extend into the areas of construction and maintenance. Greater assurance of a fair return on the taxpayer's dollar is realized through improved means of obtaining the quality of construction prescribed by the contract as well as a significant means of controlling the time limits within which the facility construction will be completed. Maintenance, in turn, is furnished with a means for obtaining better control over efficiency and effectiveness through the use of standards. The budget becomes a mechanism for overall public works cost, performance, and efficiency control at the local activity level.

In essence, it is considered that although each element offers advantages, the only way to achieve the maximum benefit of the proposed system is to realize the existence of the very vital and meaningful relationships between the various functions and to capitalize on them. In short, the entire effort must be toward maximum resource utilization through a fully integrated approach to all of the Bureau's management functions.

As a final word, it would appear that the Bureau would do well to put all possible emphasis on its integrated management studies. With the amount of expressed interest in the various facets of military management of facilities, it would appear to be only a matter of time before new techniques of requirements analysis and performance evaluation are devised.

> I must Create a System, or be enslav'd by another Man's;
> I will not Reason and Compare; my business is to Create.
>
> -William Blake (1757-1827)[1]

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[1] J. M. and M. J. Cohen, The Penguin Dictionary of Quotations (New York: Atheneum, 1962), p. 59.

TABLE 1

FACILITY ANALYSIS CODES, EXPENDITURE ACCOUNTS, REAL PROPERTY CATEGORY CODES AND MEASUREMENT UNITS, FOR FISCAL YEAR 1963

Facility Analysis Code	DESCRIPTION	Expenditure Accounts New (1963)	Expenditure Accounts Old (1962)	Real Property Category Codes*	Measurement Units** #1	Measurement Units** #2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
001	Concrete Runways	44200	44200	11110	SY	
002	Bituminous Runways	44201	44201	11111	SY	
003	Other Airfield Pavement, Concrete	44207	44203 44207 44211 44215	11120, -30, -90, 11210 11310, -20, -30, -40, -50, -90 11610, -20, -30, -90	SY	
004	Other Airfield Pavement, Bituminous	44208	44204 44208 44212	11121, -31, -91, 11211 11311, -21, -31, -41, -51, -91 11611, -21, -31, -91	SY	
005	Other Airfield Pavement	44209	44202 44205 44209 44213 44216	11112, 11122, -32, -92, 11212 11312, -22, -32, -42, -52, -92 11612, -22, -32, -92	SY	
006	Liquid Fuel Dispensing Facilities	44218	44218 thru 44228 44244 44245 44246	121, 122, 123, 126		
007	Operating Fuel Storage Facilities	44230	44230 thru 44234	124	GA	
008	Liquid Fuel Distribution Facilities	44236	44236 thru 44241	125	MI	
009	Communication, Navigation & Traffic Aids Bldgs. - Permanent	44248	44248 44250 44252 44254 44256 44258 44260 44266 44268 44270 44272	(131, 133)PB	SF	
010	Communication, Navigation & Traffic Aids Bldgs. - Nonpermanent	44249	44249 44251 44253 44255 44257 44259 44261 44267 44269 44271 44273	(131, 133)NPB	SF	
011	Communication, Navigation & Traffic Aids Facilities Other Than Buildings or Lines	44264	44264 44276	132, 134		
012	Communication Lines	44278	44278	135	MI	
013	Airfield Pavement Lighting	44280	44280 44281 44282	136	FT	
014	Air Term., Aircr. Line, Oper'ns & Control Tower Bldgs. - Perm.	44284	44284	(14110, -30, -40, -70)PB	SF	
015	Air Term., Aircr. Line, Oper'ns & Control Tower Bldgs. - Nonperm.	44285	44285	(14110, -30, -40, -70)NPB	SF	
016	Other Land Operational Buildings - Permanent	44286	44286 44288 44290 44294	(14120, -50, -60, -80, -90)PB 142 PB	SF	
017	Other Land Operational Buildings - Nonpermanent	44287	44287 44289 44291 44295	(14120, -50, -60, -80, -90)NPB 142 NPB	SF	
018	Land Operational Facilities Other Than Buildings	44297	44296 44297	142 S, 149		
019	Piers	44298	44298 44299 44300	151	SY	FB
020	Wharves	44302	44302 44303 44304	152	SY	FB
021	Seawalls, Bulkheads, Quaywalls	44307	44307 44308 44309	154	LF	
022	Waterfront Operational Buildings - Permanent	44311	44311	159 PB	SF	
023	Waterfront Operational Buildings - Nonpermanent	44312	44312	159 NPB	SF	
024	Other Waterfront Operational Facilities	44313	44306 44313	153, 159 S		
025	Harbor Protection Facilities Buildings - Permanent	44315	44315	161 PB	SF	
026	Harbor Protection Facilities Buildings - Nonpermanent	44316	44316	161 NPB	SF	
027	Harbor & Coastal Facilities Other Than Buildings	44317	44317 44318 44319 44321	161 S, 162, 163, 164		
028	Training Buildings - Permanent	44324 44328	44324 44326 44328 44330	171 PB	SF	
029	Training Buildings - Nonpermanent	44325 44329	44325 44327 44329 44331	171 NPB	SF	

TABLE A

FACILITY ANALYSIS CODES, EXPENDITURE ACCOUNTS, REAL PROPERTY CATEGORY CODES AND MEASUREMENT UNITS, FOR FISCAL YEAR 1963

Facility Analysis Code	D E S C R I P T I O N	Expenditure Accounts New (1963)	Expenditure Accounts Old (1962)	Real Property Category Codes*	Measurement Units** FA	Measurement Units** FP
(1)	(2)	(3)	(4)	(5)	(6)	(7)
030	Training Facilities Other Than Buildings	44334	44334	179		
031	Maintenance Buildings - Permanent	44337	44337 44339 44344 44349 44352 44355 44360 44362 44367 44370 44375	(211 thru 219)PB	SF	
032	Maintenance Buildings - Nonpermanent	44338	44338 44340 44345 44350 44353 44356 44361 44363 44368 44371 44376	(211 thru 219)NPB	SF	
033	Ship Repair Graving Docks	44347	44347	21310	SF	
034	Marine Railways	44348	44348	21320	TC	
035	Other Maintenance Facilities	44377	44341 44346 44351 44354 44357 44364 44369 44372 44377	(211 thru 219)B except 21310, -20		
036	Production Buildings - Permanent	44380 44416	44380 44385 44388 44393 44396 44401 44403 44408 44413 44418	(221 thru 229)PB	SF	
037	Production Buildings - Nonpermanent	44381 44417	44381 44386 44389 44394 44397 44402 44404 44409 44414 44417 44419	(221 thru 229)NPB	SF	
038	Shipbuilding Ways	44390	44390	22320	SC	
039	Shipbuilding Drydocks	44391	44391	22330	SF	
040	Other Production Facilities	44420	44382 44387 44392 44395 44398 44405 44410 44415 44420	(221 thru 229)B except 22320, -30		
041	Research, Development & Test Buildings - Permanent	44424	44424 44426 44428 44430 44432 44434 44436 44438 44440 44442 44444 44446 44448 44450 44452 44454	310 PB	SF	
042	Research, Development & Test Buildings - Nonpermanent	44425	44425 44427 44429 44431 44433 44435 44437 44439 44441 44443 44445 44447 44449 44451 44453 44455	310 NPB	SF	

TABLE 1

FACILITY ANALYSIS CODES, EXPENDITURE ACCOUNTS, REAL PROPERTY CATEGORY CODES AND MEASUREMENT UNITS, FOR FISCAL YEAR 1963

Facility Analysis Code	D E S C R I P T I O N	Expenditure Accounts New (1963)	Expenditure Accounts Old (1962)	Real Property Category Codes*	Measurement Units** #1	Measurement Units** #2
(1)	(2)	(3)	(4)	(5)	(6)	(7)
083	Bachelor Officers Quarters - Permanent	44602	44602	724 PB	SF	
084	Bachelor Officers Quarters - Nonpermanent	44603	44603	724 NPB	SF	
085	Emergency Troop Housing Facilities	44606	44606 44607	725	SF	
086	Personnel Support & Service Buildings - Permanent	44609	44609 44611 44613 44615 44617 44619 44621 44623 44625 44627 44629	730 PB	SF	
087	Personnel Support & Service Buildings - Nonpermanent	44610	44610 44612 44614 44616 44618 44620 44622 44624 44626 44628 44630	730 NPB	SF	
088	Personnel Support & Service Facilities Other Than Buildings	44631	44631	730 S		
089	Morale, Welfare & Recreation Buildings - Permanent	44634	44634 44636 44638 44640 44642 44644 44646 44648 44650 44652 44654 44656 44658 44660 44662	740 PB	SF	
090	Morale, Welfare & Recreation Buildings - Nonpermanent	44635	44635 44637 44639 44641 44643 44645 44647 44649 44651 44653 44655 44657 44659 44661 44663	740 NPB	SF	
091	Exterior Morale, Welfare & Recreation Facilities	44666	44666	750		
092	Electricity Generating Plants	44668	44668 thru 44675	811	KV	
093	Electricity Distribution & Transmission Systems	44678	44678 thru 44683	812	LF	
094	Heating Plants	44686 44688	44686 thru 44694	82110, -20, -30	MP	MB
095	Steam Power Plant	44698	44698 thru 44705	82150	MP	MB
096	Steam & Hot Water Distribution Lines	44709	44709 44710 44711	822	LF	
097	Gas [illegible] Plants & Storage Facilities	44713	44713 44714	823	GY	
098	[illegible] & Transmission Lines	44716	44716	824	LF	
099	Sewage & Industrial Waste Treatment & Disposal Fac.	44718	44718 thru 44721	831		
100	Sewage & Industrial Waste Collection Facilities	44725	44725 thru 44728	832	LF	
101	Refuse & Garbage Collection & Disposal Facilities	44731	44731 44732 44733	833		
102	Water Supply, Treatment & Storage Facilities	44735	44735 thru 44741	841	GA	MG
103	Potable Water Distribution Facilities	44746	44745 44746	84210, -15	LF	
104	Non-Potable Water Distribution Facilities	44748	44747 44748	84230, -35	LF	
105	Fire Protection Water System	44751	44751 thru 44755	843	LF	GM

APPENDIX B

THE DISCOUNT METHOD

By means of interest calculations it is possible to determine an amount of money at any given time which is equivalent to a stated amount of money at some other time. For example, if an interest rate of 5% per annum is used, $1.00 now and $1.05 a year from now may be said to be equivalent to each other. Discount analysis is a specific method of using interest calculations to determine a single amount of money which is equivalent to a series of annual cash payments, and that is added to the first cost of an asset, so as to give a single amount that is equivalent to both first cost and annual cash disbursements.

Discounting utilizes two interest factors, the Single Payment Present Worth Factor and the Uniform Payment Series Present Worth Factor as follows:

I. Single Payment Present Worth Factor.

Given S, find P using the factor $\frac{1}{(1+i)^n}$.

This factor, when multiplied by a future amount, will give the present worth of the future amount. For example, at 6% interest a businessman could afford to make a payment of $233 now to avoid making a payment of $1,000 25 years from now.

II. Uniform Payment Series Present Worth Factor.

Given R, find P using the factor $\frac{(1+i)^n-1}{i(1+i)^n}$.

This factor, when multiplied by one of a series of equal end-of-period payments, gives the present worth at the beginning of the period. For example, at 6% a businessman could afford to make a single payment of $7,360 now to avoid making a payment of $1,000 at the end of each year for the next 10 years. In the foregoing formulae:

i=interest rate per interest period.
n=number of interest periods.
P=present sum of money.
R=a single end-of-period payment in a series of n equal payments made at uniform intervals, the entire series being equivalent to P.
S=a sum of money n periods hence, which is equivalent to either P or R at interest rate i.

Use of the discount method also makes it possible to find the present worth of a series of payments that take place between any two time periods. For example, to find the present worth of $2,000 annual payments that take place from years 11 to 15 inclusive, it is necessary to multiply the amount of one payment by the Uniform Payment Series Present Worth Factor for n=5, that is, for years 11 to 15. This will give the "present" worth of the payment series at the beginning of the series; i.e., at year 10. This value must then be multiplied by the Single Payment Present Worth Factor for n=10 to find the actual present worth of the uniform payment series. Thus the present worth of the $2,000 uniform payment series at 6% is $2,000 (4.212) (.5584) $4,707. (W. G. Ireson and E. L. Grant (eds.), <u>Handbook of Industrial Engineering and Management</u> (Englewood Cliffs: Prentice Hall, 1955), pp. 108-129).

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